Compressed Air Magazine

APRIL 1945

BOMB-BAY DOORS OPENED BY AIR

Pneumatic controls enable Superfortresses to start their bombing runs without drawing enemy fire.

VOLUME 50 • NUMBER 4

NEW YORK • LONDON

WHEN your equipment calls for small horsepower, you're saving money when a Coppus "Blue Ribbon" Steam Turbine is on the job.

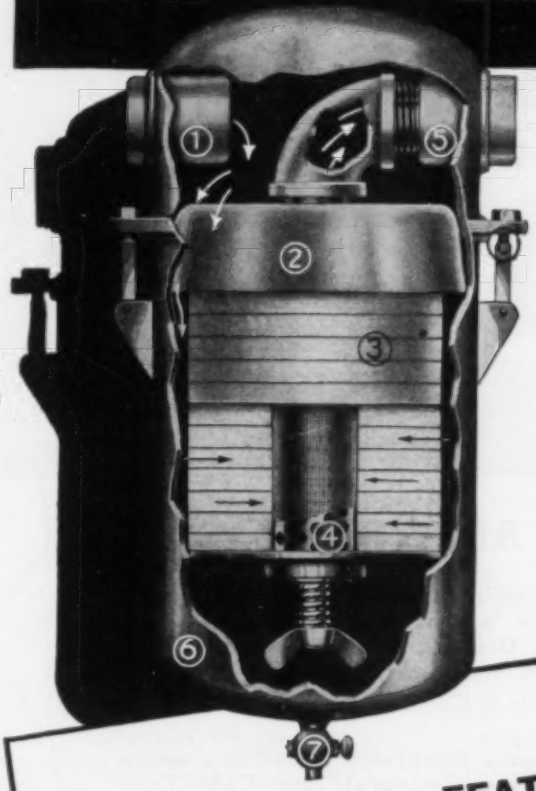
Coppus makes turbines in six frame sizes from 150 HP down to fractional — so you can "fit" the power more closely to the need. No reason to pay extra for ordinary "elephant power" turbines, when you have a small horsepower requirement.

Many well-known manufacturers of original equipment have selected Coppus turbines. And they are to be found on U. S. destroyer escorts, driving vertical lubricating oil pumps . . . on U. S. Casablanca class aircraft carriers, driving main and auxiliary circulating pumps and fire pumps . . . on more than 90% of all Landing Ship Docks, driving condensate and clean ballast pumps.

A job for a Jeep, not a Truck

You, too, can rely on their dependable performance to meet your requirements for "jeep" power. Like all Coppus "Blue Ribbon" products (blowers, ventilators, gas burners, etc.), the Coppus turbine is a precision-made product — its accuracy controlled by Johansson size blocks — and every turbine is dynamometer-tested before shipment. Since 1937, more than 85% of orders have been repeat orders. Write for Bulletin 135-10. COPPUS ENGINEERING CORPORATION, 204 Park Avenue, Worcester, Mass. Sales Offices in THOMAS' REGISTER. Other products in SWEET'S, CHEMICAL ENGINEERING CATALOG, REFINERY CATALOG.

HAZARD of Oil and Moisture in Automatic Controls NOW ELIMINATED



New Filter Delivers Dry Air Only

Amazing results are being reported by users of the Model AAPHS Pipe Line Filter as a final stage in the protection of delicate pneumatic control instruments.

Typical comment is that of a large producer of electric and steam power who says, "We tried several well-known methods of moisture and oil elimination without satisfactory results. Your Model AAPHS was finally installed in the air line and since then we have had no trouble whatever with oil or moisture in our automatic controls."

NEW 44-PAGE CATALOG: Describes entire line, including filters for building ventilation, pipe lines, engine, and compressor intakes. Your copy is ready.

DOLLINGER CORPORATION
(Formerly Staynew Filter Corp.)
7 CENTRE PARK, ROCHESTER 4, N. Y.

"Air Filter Headquarters"

STAYNEW PROTECTOMOTOR FILTERS

CONSTRUCTION FEATURES

(1) inlet; (2) baffle that distributes vapor-laden air to sides of container (6); (3) felt rings; (4) perforated liner; (5) outlet; (7) drain cock; (8) swing bolts for easy inspection (optional).

THICK FELT RINGS that remove every trace of oil or moisture.

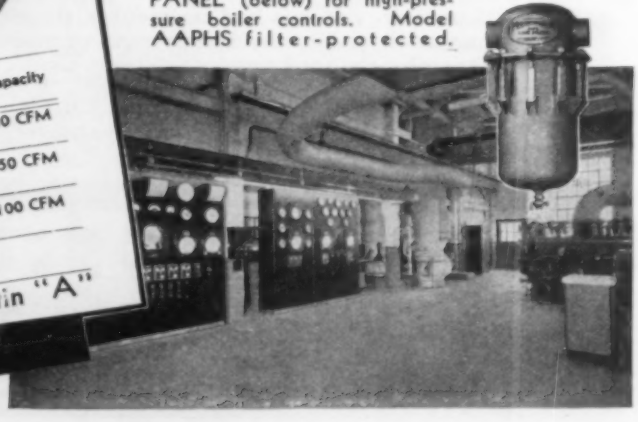
SPECIFICATIONS

Model	Standard Pipe Size	Capacity
AAPH-02 AAPHS-02	¼"	5 CFM
AAPH-01 AAPHS-01	¼"	7 CFM
AAPH-0 AAPHS-0	½"	10 CFM
AAPH-1 AAPHS-1	¾"	20 CFM
AAPH-2 AAPHS-2	1"	30 CFM
AAPH-4 AAPHS-4	1½"	50 CFM
AAPH-5 AAPHS-5	2"	100 CFM

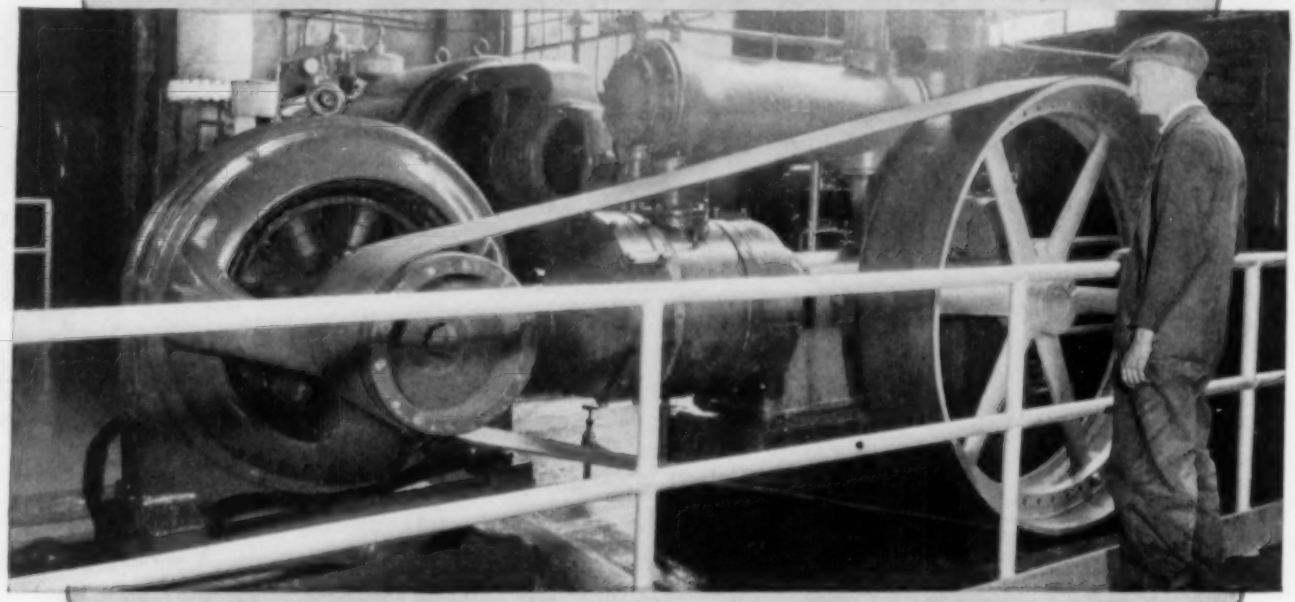
Letter S in code numbers indicates swing-bolt type which facilitates inspection.

Write for Bulletin "A"

PANEL (below) for high-pressure boiler controls. Model AAPHS filter-protected.



"We have found this type drive to be very efficient and economical . . . has been in service 10 hours or more every day since 1931. Original belt is still in use and appears to have many years' service left in it."



HERE'S THE VIM DRIVE . . . AND THE REASON:

The above compressor was originally direct connected to a steam engine. When the shaft broke, the plant intended to drive the compressor with a 125 H.P. 100 K.W. motor, using an 8" belt. The belt would not handle the load.

The Houghton engineer recommended that a steel band be sweated on the driven cast iron pulley to increase its width, and that a 14" Double VIM Belt be installed, with the motor mounted on a pivoted base to maintain constant, correct tension. That was back in 1931.

Now, fourteen years later, the superintendent of that plant reports as above. He was able to increase his air pressure 25 pounds, and has had no trouble since then with either the compressor or the transmission hook-up.

This instance proves two things: First, that the Houghton engineer knows power transmission and can help the man in trouble. Secondly, that the VIM Efficiency Drive (a pivoted motor base plus a VIM Tred Leather Belt) will deliver the full amount of power a compressor needs.

Because a compressor drive is a tough job, it's a "natural" for VIM Tred Leather with a tension-controlled drive. The advantages you will get from such a drive include:—longer belt life . . . less strain on bearings . . . less slippage when starting . . . correct tension automatically maintained . . . no need for frequent take-ups.

How about *your* compressor drives? Can we help make them more efficient?

E. F. HOUGHTON & CO.
PHILADELPHIA
CHICAGO · SAN FRANCISCO · DETROIT

Houghton's TREADED LEATHER BELTING

Cooling Concrete 120 TIMES FASTER!

HEAT from hydration of cement in the 2,800,000 cu. yds. of concrete used in building TVA's Fontana Dam would normally take 40 years to dissipate completely. However, by circulating water—cooled by a 250-ton-per-day refrigeration plant—through pipes embedded in the concrete, the required cooling and shrinking was accomplished in two to six months, an average of 120 times faster.

Speedy completion of giant projects like Fontana is due not only to improved methods of cooling concrete, but also to improved construction machinery and improved lubricants designed to assure their maximum performance. In the development of lubricants, Texaco has played a leading role.

Texaco Alcaid, Algol or *Ursa Oils* in air compressors, to cite one example, assure wide-opening, tight-shutting valves, free piston rings, open ports, clear lines, continuous air supply. They also assure maximum service life between overhauls, fewer repairs and replacements. Their use in compressors is worldwide.

Texaco lubricants have proved so effective in service they are definitely preferred in many fields, a few of which are listed at the right.

Texaco Lubrication Engineering Service is available through more than 2300 Texaco distributing plants in the 48 States. Get in touch with the nearest one, or write The Texas Company, 135 East 42nd Street, New York 17, N. Y.

THEY PREFER TEXACO

★ More revenue airline miles in the U. S. are flown with Texaco than with any other brand.

★ More buses, more bus lines and more bus-miles are lubricated with Texaco than with any other brand.

★ More stationary Diesel horsepower in the U. S. is lubricated with Texaco than with any other brand.

★ More Diesel horsepower on streamlined trains in the U. S. is lubricated with Texaco than with all other brands combined.

★ More locomotives and railroad cars in the U. S. are lubricated with Texaco than with any other brand.

TEXACO

REG. T.M.

TEXACO Lubricants

FOR ALL AIR COMPRESSORS AND TOOLS

TUNE IN THE TEXACO STAR THEATRE WITH JAMES MELTON EVERY SUNDAY NIGHT—CBS

Eimco
Rocker Shovel
Model 40

Model 40 RockerShovel loading iron ore weighing 240 lbs. per cu. ft. into 6 ton capacity cars.

The Model 40 RockerShovel operates in wide headings and is an ideal high-tonnage machine for any tunnel excavation. This machine is operated by one man and loads at the rate of 4 to 5 tons per minute. The ½ cu. yd. bucket operates from any digging angle directly onto a live conveyor belt. RockerShovel Model 40 features include power swing, air or electric motor drives, anti-friction bearings throughout, and the famous Eimco "Rocker-Arm" mucking action insures dependability. Write for information.

EIMCO

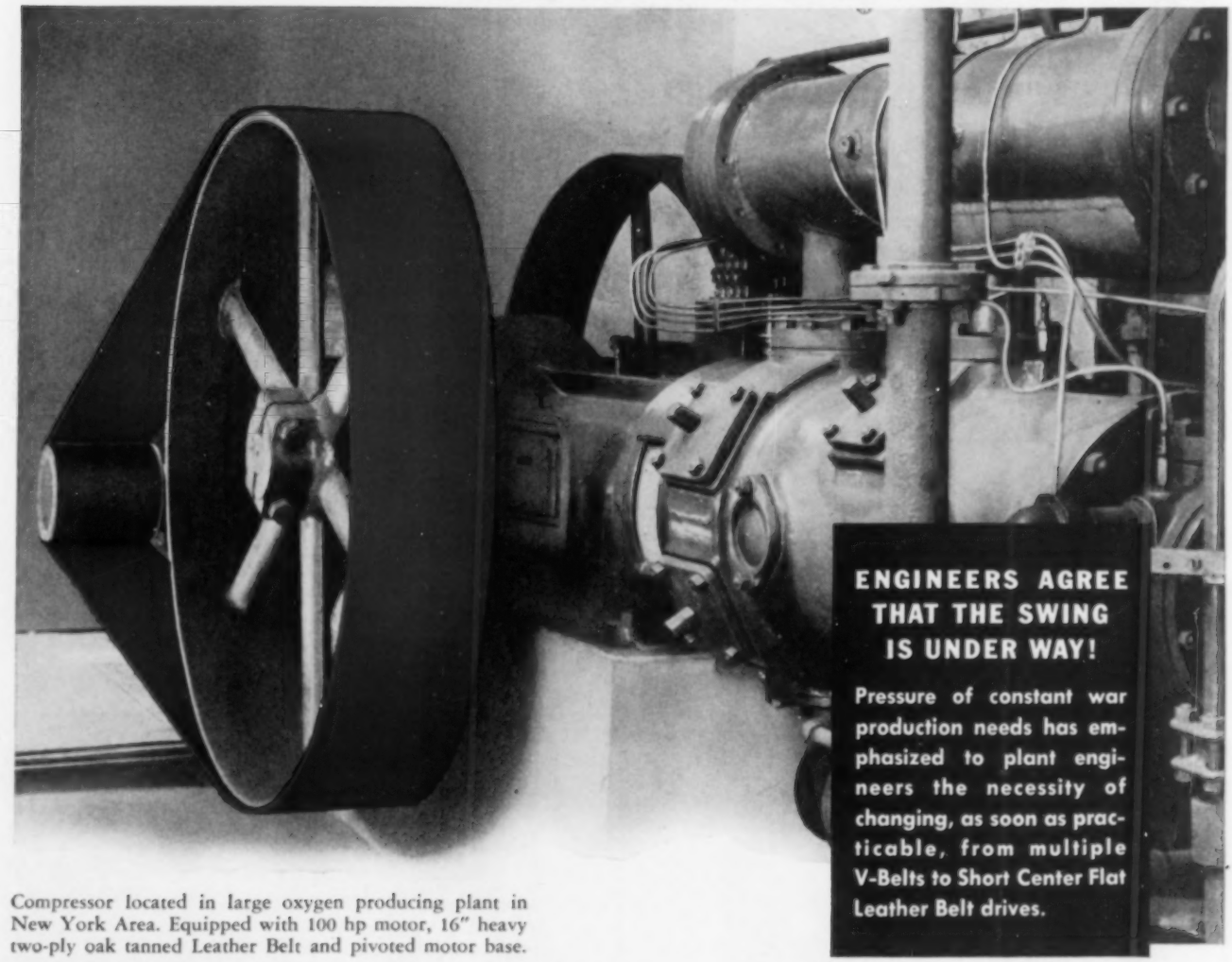
THE EIMCO CORPORATION

Executive Offices and Factories Salt Lake City 8, Utah
Branches: New York, Chicago, El Paso, Sacramento, St. Louis

NATION WIDE
AIR FILTER SERVICE
Dotting the nation from border to border and coast to coast are Air-Maze factory representatives. They are competent air filtration engineers trained, experienced, and ready to assist you with your air filtration problems.
Take advantage of this Air-Maze service because Air-Maze has specialized in engineered, precision-built air filters for twenty years. So, whether your interest applies to air conditioning, ventilating, compressors, blowers or engines, you can have *engineered air filtration* in every Air-Maze filter.
Typical Air-Maze Panel for heavy-duty service.
Air-Maze air filters are constructed of metal throughout. They are easily washable—last indefinitely. For further data on types and application send for catalog AGC-144. And remember—"If it uses air, use AIR-MAZE".
AIR-MAZE CORP. • CLEVELAND 5, O.
Representatives in Principal Cities. In Canada: Williams & Wilson, Ltd., Montreal, Quebec, Toronto, Windsor; Fleck Bros., Ltd., Vancouver.
ARMY NAVY
IF IT USES AIR...USE
AIR-MAZE
ENGINEERED AIR FILTRATION

ONLY *Leather Belting* CAN DO THIS JOB PROPERLY

"INDUSTRY LEARNS BEST FROM EXPERIENCE"



ENGINEERS AGREE THAT THE SWING IS UNDER WAY!

Pressure of constant war production needs has emphasized to plant engineers the necessity of changing, as soon as practicable, from multiple V-Belts to Short Center Flat Leather Belt drives.

Compressor located in large oxygen producing plant in New York Area. Equipped with 100 hp motor, 16" heavy two-ply oak tanned Leather Belt and pivoted motor base.

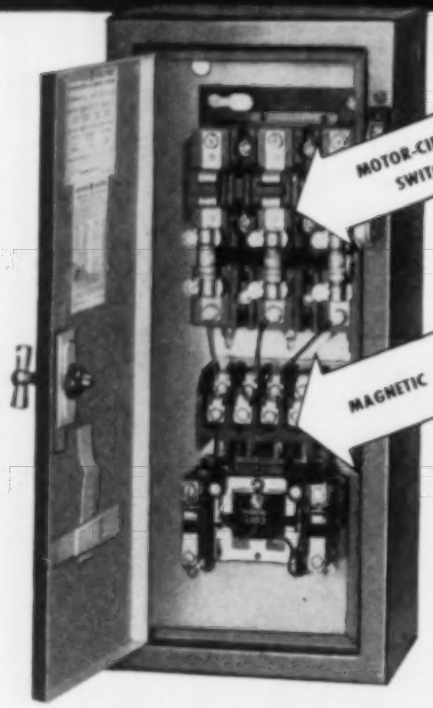
Here's Why Leather Belting is Best For You, Too . . .

It is a recognized fact that Leather has the longest life of any known belting material. Its tough, fibrous structure gives it greater resistance to wear, tear and abrasion. Plant operators know that Leather Belting can withstand heavy shock loads, "giving" enough to prevent damage to bearings, yet recovering when the load becomes normal. Leather Belting actually improves with use — a unique quality found in no other type of belting. The long life, ease of installation and maintenance and economical operation of Leather Belting — often over 10, 20 and even 40 years, as reported by many reputable, old-established companies — contrasts sharply with plant operators' experiences when using belting of other material or design. That's why so many of them say:

"YOU WILL HAVE FEWER SHUTDOWNS WITH LEATHER BELTING"

AMERICAN LEATHER BELTING ASSOCIATION · 41 Park Row, NEW YORK 7, N. Y.

MOTOR STARTERS—EVERY TYPE, EVERY KIND, FOR EVERY MACHINE APPLICATION



TWO DEVICES IN ONE UNIT

You Can Save 6 Ways with Combination Starters

1. **They Save Money**—Through savings in wire, conduit, fittings, and installation costs.
2. **Save Ordering Time**—Instead of buying two separately mounted devices, you buy one factory co-ordinated unit.
3. **Speed Up Installation**—You connect only 9 terminals—not 15.
4. **Save Wall Space**—You can mount combination starters in small, unused places.
5. **Conserve Man Power**—By eliminating one complete mounting job on every installation.
6. **Save Critical Materials**—Combination starters have less wire and steel conduit and fewer fittings than separately mounted devices.

DEPENDABLE ★ ATTRACTIVE IN APPEARANCE ★ DESIGNED TO BLEND WITH MODERN MACHINES

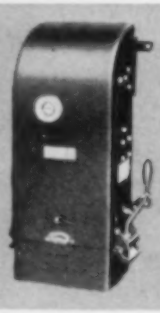
WHAT IS YOUR APPLICATION

G-E starters come in a variety of enclosures to meet any operating conditions. We'd like to send you any additional information you may want. *General Electric Company, Schenectady 5, New York.*

MOTOR-STARTING SWITCH

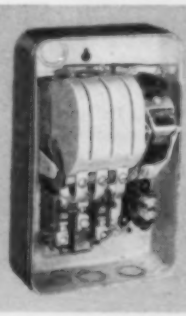
Recommended for full-voltage starting of small motors. Manually operated.

REDUCED-VOLTAGE STARTER



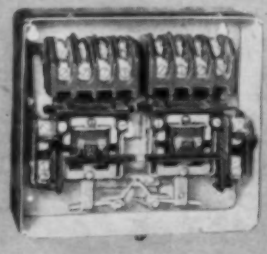
A manual, autotransformer-type starter for squirrel-cage induction motors.

A-C MAGNETIC STARTER



For use as a full-voltage starter of squirrel-cage motors, or as a primary switch for wound-rotor induction motors.

A-C MAGNETIC REVERSING SWITCH



For applications where it is necessary to run the motor in forward and reverse directions.

Buy all the BONDS you can—and *keep all you buy*

GENERAL ELECTRIC

678-134C

SECURITY.....

The first requirement of any machine is that it will stay on the job. Protection against mechanical troubles and breakdowns is assured by the simplicity of Ingersoll-Rand design and the high standards of manufacture, materials and service maintained by the Company.

COMPRESSORS
•
TURBO BLOWERS
•
AIR TOOLS
•
ROCK DRILLS
•
CENTRIFUGAL PUMPS
•
CONDENSERS
•
OIL & GAS ENGINES

Ingersoll-Rand

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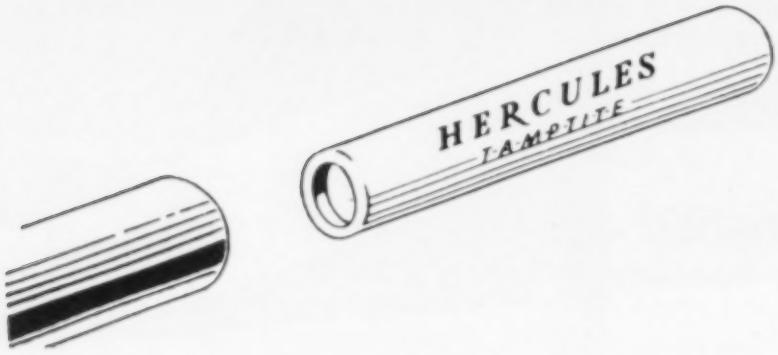
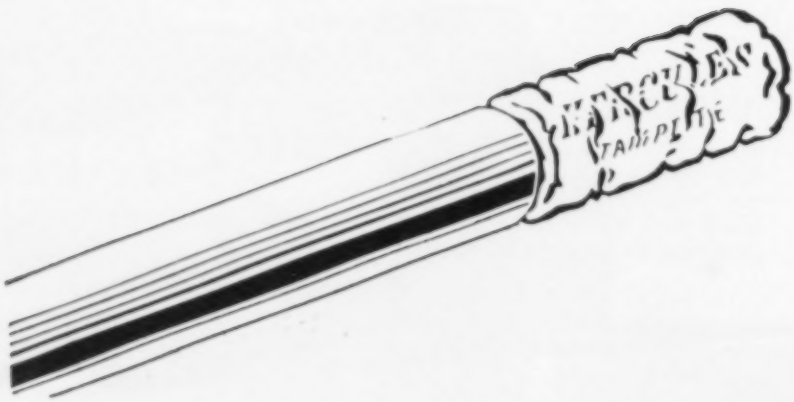


TAMPTITE

SAVES MAN-HOURS



You save time, labor, and expense with Hercules explosives in Tamptite cartridges—important savings in a period of manpower shortages.

You drill and tamp in the usual way, using your favorite Hercules explosive. But when you tamp a Tamptite cartridge, the dynamite expands to fill the bore hole snugly, leaving virtually no air space. (No need to slit cartridges and risk spilling powder.) The charge is concentrated where it is most effective.

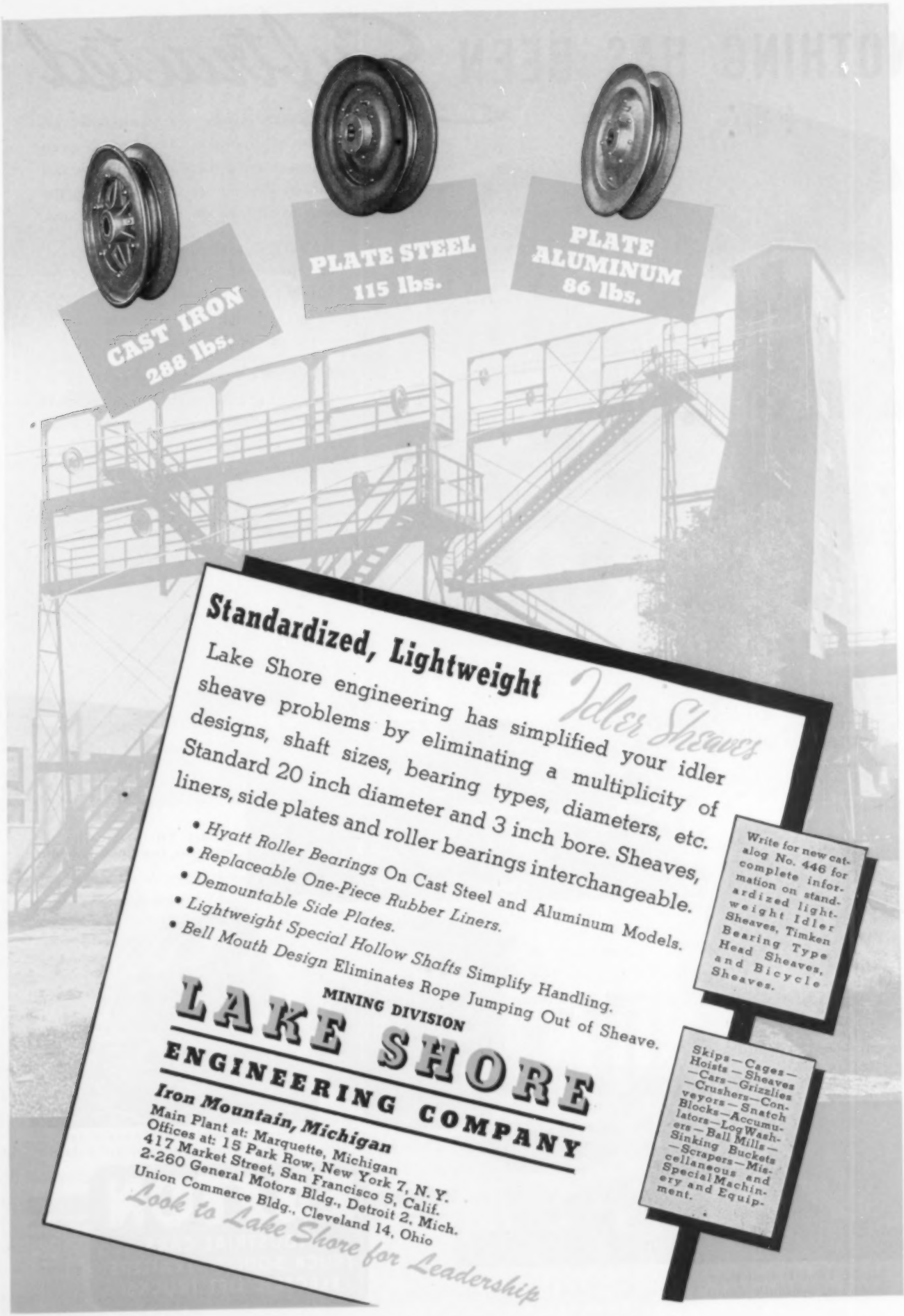
Result: Better breakage of the ore or rock, speedier mucking, a faster mining cycle. Man-hours saved!

Hercules Gelamites, Hercomites*, Extra Gelatins, Gelatins, and Extra Dynamites —in small sizes for mining, quarrying, and construction—are furnished in Tamptite cartridges. This is another reason for specifying Hercules.*

EXPLOSIVES DEPARTMENT, *HERCULES POWDER COMPANY* **932 KING STREET, WILMINGTON 99, DELAWARE**

*REG. U. S. PAT. OFF. BY HERCULES POWDER COMPANY INCORPORATED

XR-53


CAST IRON
288 lbs.
PLATE STEEL
115 lbs.
PLATE ALUMINUM
86 lbs.
Standardized, Lightweight Idler Sheaves
Lake Shore engineering has simplified your idler sheave problems by eliminating a multiplicity of designs, shaft sizes, bearing types, diameters, etc. Standard 20 inch diameter and 3 inch bore. Sheaves, liners, side plates and roller bearings interchangeable.
• Hyatt Roller Bearings On Cast Steel and Aluminum Models.
• Replaceable One-Piece Rubber Liners.
• Demountable Side Plates.
• Lightweight Special Hollow Shafts Simplify Handling.
• Bell Mouth Design Eliminates Rope Jumping Out of Sheave.
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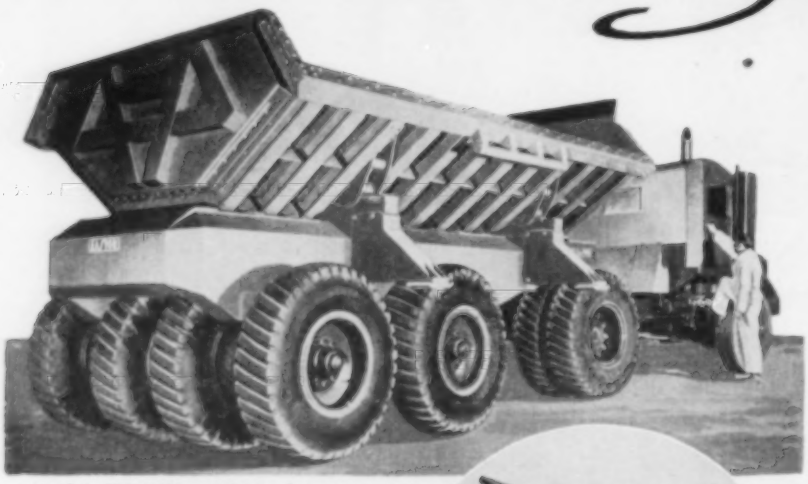
Look to Lake Shore for Leadership
Write for new catalog No. 446 for complete information on standardized lightweight Idler Sheaves, Timken Bearing Type Head Sheaves, and Bicycle Sheaves.
Skips—Cages—Hoists—Sheaves—Cars—Grizzlies—Crushers—Conveyors—Snatch Blocks—Accumulators—Log Washers—Ball Mills—Sinking Buckets—Scrapers—Miscellaneous and Special Machinery and Equipment.

NOTHING HAS BEEN *Subtracted*

EASTON's store of "know-how" on haulage problems has grown even greater during the War. Many new and unique designs are today showing the way to high production and low costs.

EASTON has the answer to most haulage questions . . . especially those involving such factors as track gauge, body type, method of dumping, size of tires, type of prime mover, etc.

EASTON's experience since 1914 in the mining and quarrying industries is your assurance of good counsel. Write to Engineering Counsel, Easton Car & Construction Company, Easton, Pa.



Model TR-15T trailerized mine car, eight oscillating wheels, side dumping

Model TG-710 trailerized mine car, automatic down fold door

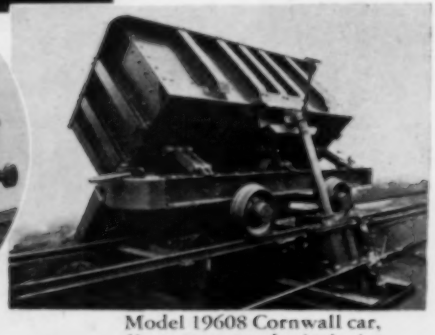
Model BB-1830 truck body, overhead hoist

Model 472 Phoenix car, either side dump

Model TR-15D trailerized mine car, two Phoenix bodies

Model 12772 Granby car, dumps in transit

Model 16030 Alpha car, bale lift skip



Model 19608 Cornwall car, floor-mounted air hoist

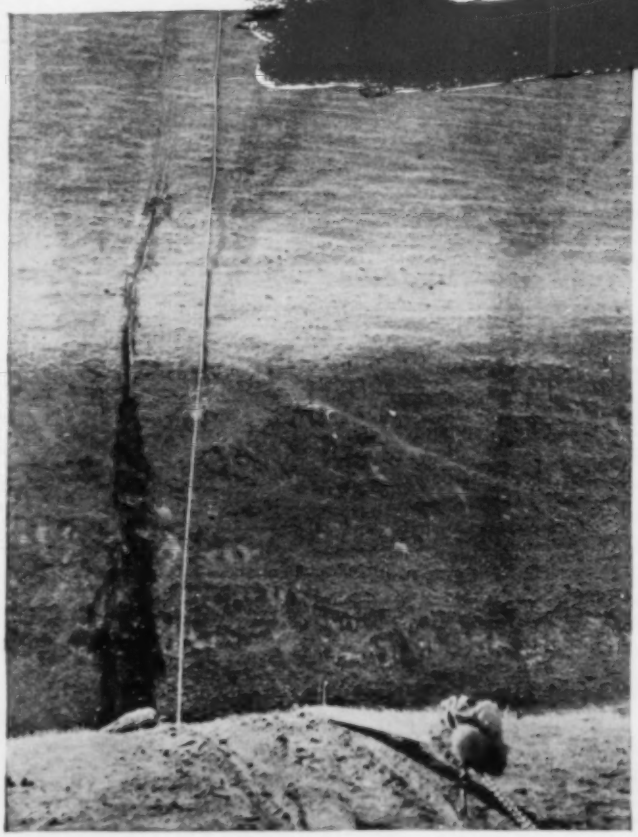
Model TR-13H trailerized mine car, hydraulic dump

EASTON

INDUSTRIAL CARS
TRUCK BODIES · TRAILERS
ELECTRIC LIFT TRUCKS

B-1017

VICTAULIC COUPLINGS CAN TAKE IT!



WESTERN OIL FIELDS SUPPLY CO.

OFFICIAL U. S. ARMY SIGNAL CORPS PHOTO

IN PEACE Here 50 sections of pipe joined by Victaulic Couplings are being hauled *in one piece* up and down hills and across ravines! Under such rugged conditions each coupling is subject to terrific strains of pull and sag. Yet not a single coupling gave way, in 15,000 feet of pipeline!

OR WAR! This is an Army pipeline spanning a river — more than a dozen pipe sections are joined by Victaulic Couplings. Not only can Victaulic Couplings stand up to the strain of continuous sag . . . but even the concussion of enemy bombs fail to disturb their tough grip.

THE two special features of built-in flexibility and mechanical lock make Victaulic Couplings specially suitable for tough jobs, in war or peace. The simplicity of their assembly gives Victaulic the extra advantage of speed, and low-cost installation. For full details of the famed Victaulic self-aligning pipe couplings and full-flow fittings write to: VICTAULIC COMPANY OF AMERICA, 30 Rockefeller Plaza, New York 20, N. Y. Other Victaulic offices—Victaulic Inc., 727 West 7th St., Los Angeles 14, California; Victaulic Co. of Canada, Ltd., 200 Bay St., Toronto, Ontario, Can.

VICTAULIC

Reg. U. S. Pat. Off.

SELF-ALIGNING PIPE COUPLINGS AND FULL-FLOW FITTINGS

Copyright 1945 by Victaulic Co. of America

War Bonds - a pipe line from you to him.

OIL **MINING** **MARINE** **MUNICIPAL** **INDUSTRIAL**

3 CONDENSING PLANTS

Since October, 1939, three new generating units, built and designed by Stone & Webster Engineering Corporation, for a Southeastern utility have been placed in operation. The surface condensing plants for all three turbine-generators were built by Ingersoll-Rand.

FIRST CONDENSER INSTALLED AND TESTED

In recommending Ingersoll-Rand for the first new unit, the contracting engineers spoke with the confidence based upon the many hundreds of outstanding I-R condenser installations, not a few of which Stone & Webster had installed. Tests made on the first condenser, a single-pass divided type serving a 40,000-kw generator unit, showed that performance guarantees for all operating conditions were exceeded by a wide margin. Moreover, the station operating manager called attention to the fact that the I-R hotwell construction provided condensate almost entirely free of oxygen and reheated it to inlet temperatures.

Ingersoll-Rand equipment serving this condenser included a two-stage steam-jet air ejector, vertical propeller-type condensing water circulating pump and two hotwell condensate pumps.

SECOND CONDENSER INSTALLED AND TESTED

Several months after the initial installation was placed in operation, an additional 40,000-kw generating unit was ordered for another station. The tests of the initial plant had already been made and thoroughly studied, and the efficiencies that they demonstrated influenced the selection of Ingersoll-Rand equipment.

As before, steam-jet removal equipment, as well as condensate and circulating water pumps were supplied by Ingersoll-Rand.

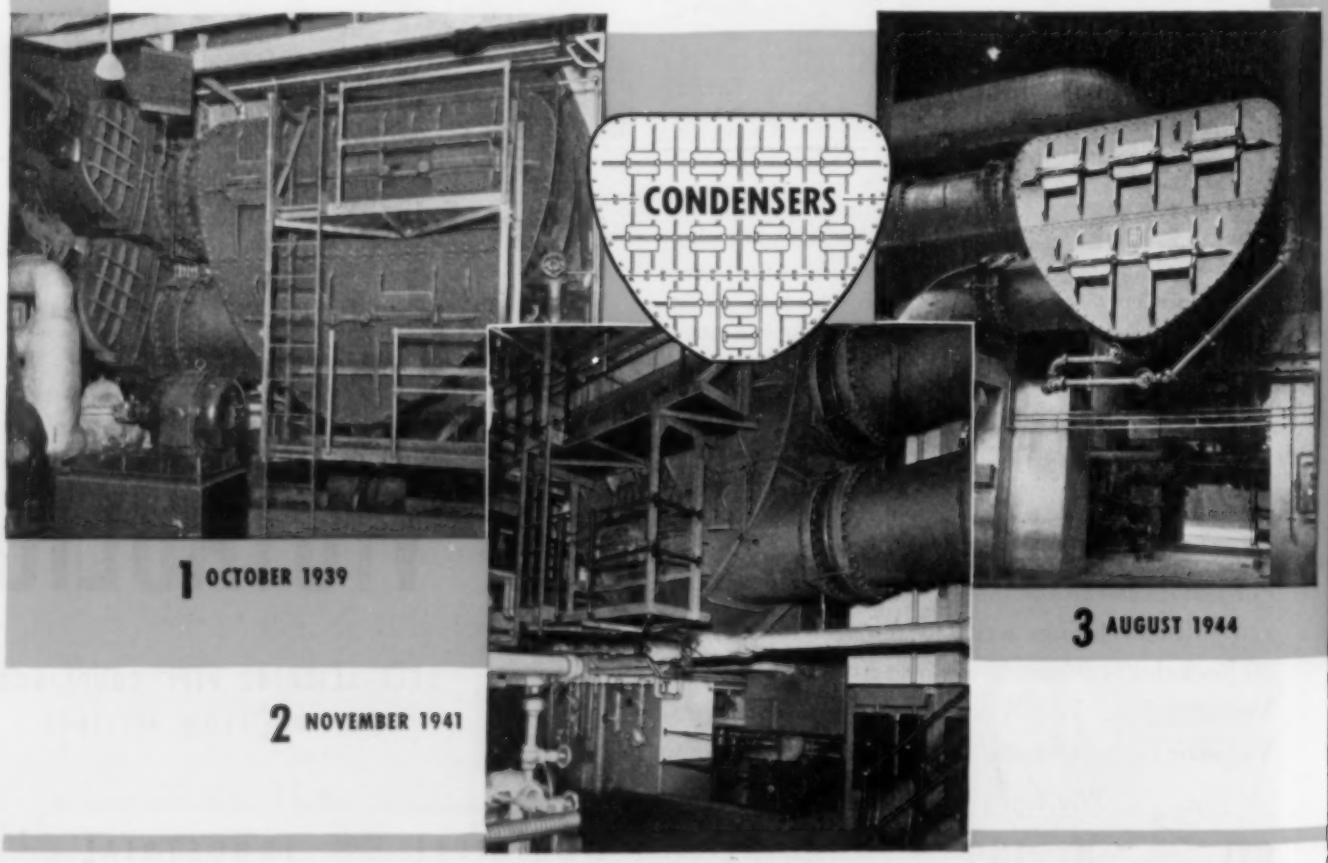
THIRD CONDENSER NOW OPERATING

In 1944, Stone & Webster completed a new plant for this same Company. One 50,000-kw turbine-generator was installed in this station, and it is served by an Ingersoll-Rand condensing plant.

This third order illustrates the confidence which both the Utility Company and Stone & Webster Engineering Corporation have in Ingersoll-Rand condensing equipment.

• • • •

Ingersoll-Rand's many years of original and progressive condenser design, the construction refinements that reduce maintenance to a minimum, and the results obtained in actual installations are sound recommendations for the selection of Ingersoll-Rand Condensing Plants.



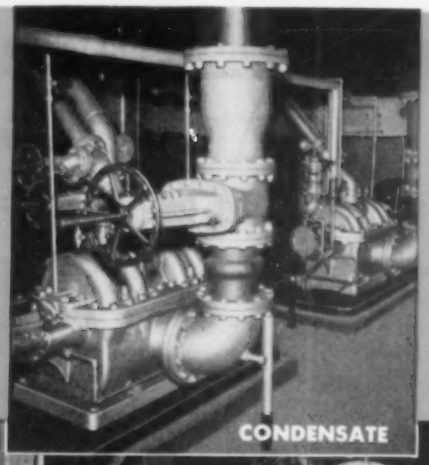
1 OCTOBER 1939

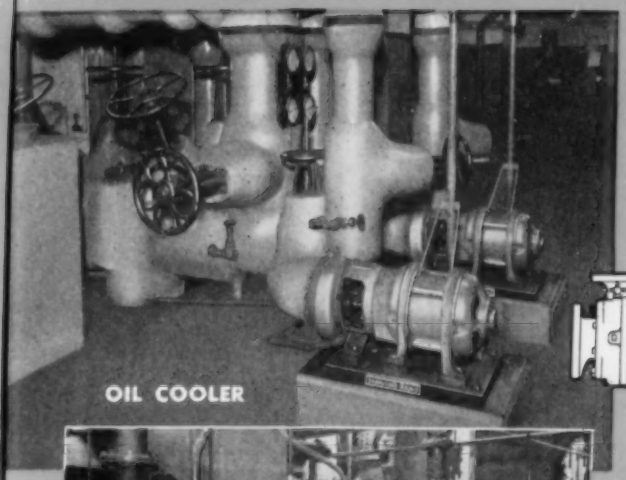
2 NOVEMBER 1941

3 AUGUST 1944

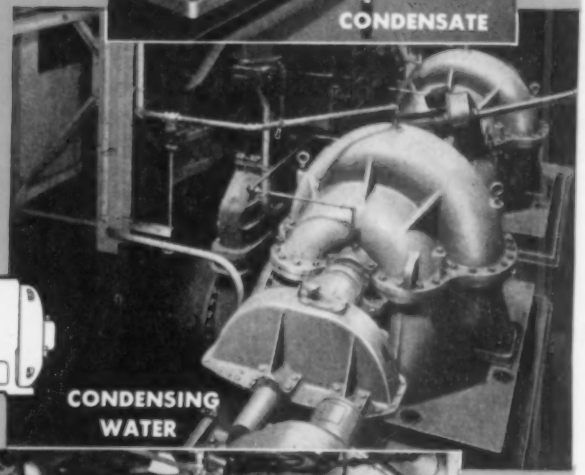
FOR 130,000 KW

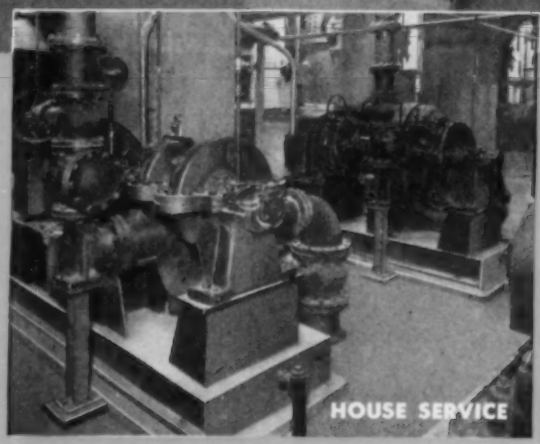
Expansion Program of a Southeastern Utility

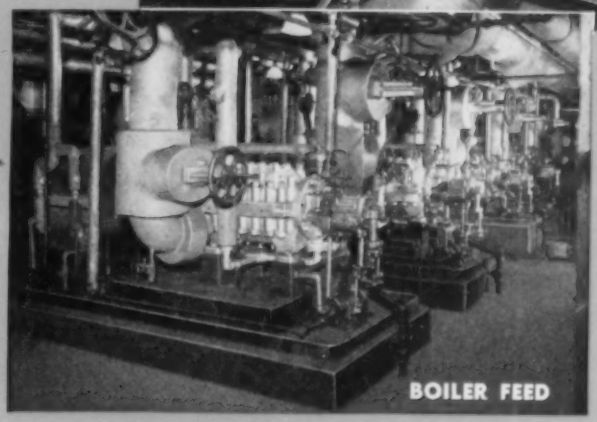




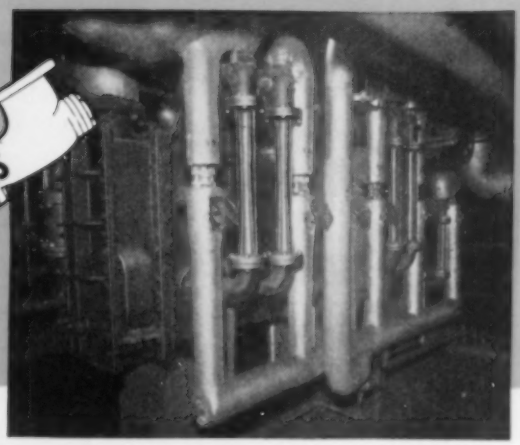
PUMPS







AIR EJECTORS



Ingersoll-Rand

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4-590

COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • OIL AND GAS ENGINES

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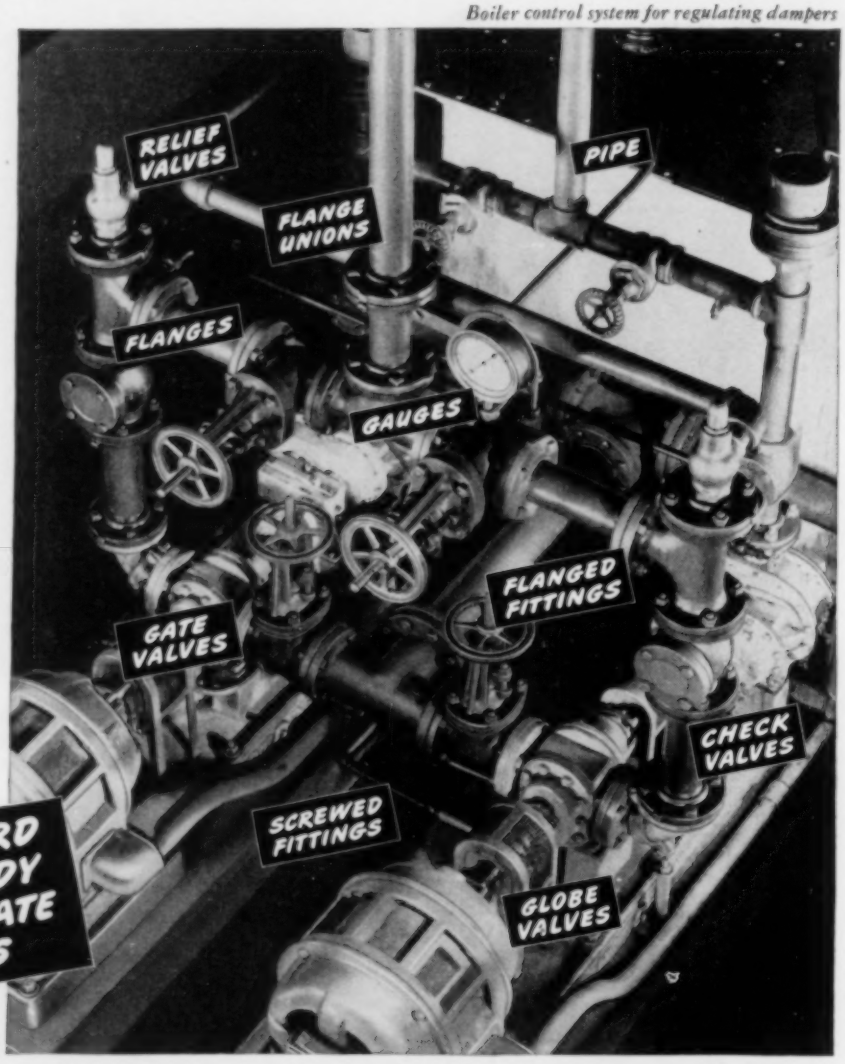
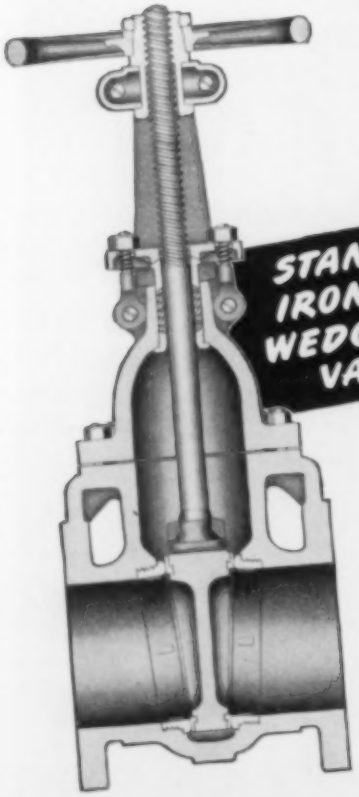
ONE SOURCE OF SUPPLY • ONE RESPONSIBILITY FOR ALL PARTS • ONE STANDARD OF QUALITY

To keep piping at its best, to simplify and speed up deferred replacements—call on the Crane line. You choose from the world's greatest selection of piping materials—in brass, iron and steel. One source—your Crane Branch or Wholesaler—supplies on one order all your requirements. Every part is uniform in quality, backed by a single responsibility. Your whole task from ordering of parts to installing them is simplified—and at the same time you are benefiting by Crane Co.'s 90-year leadership in the field of piping materials. Below is an example of Crane complete lines—in Standard Iron Body Wedge Gate Valves.

Boiler control system for regulating dampers





SERVICE RECOMMENDATIONS: **Crane Standard Iron Body Wedge Gate Valves** with Brass trim are recommended for steam, water or oil lines; all-iron valves for oil, gas or fluids that corrode brass but not iron. Made in O.S.&Y. and Non-rising Stem patterns.

Working Pressures

Size of Valve	Screwed or flanged end valves		Hub end valves
	Saturated Steam	Cold water, oil or gas, non-shock	Cold water or gas, non-shock
2 to 12 in.	125 pounds	200 pounds	200 pounds
14 & 16 in.	125 pounds	150 pounds	150 pounds
18 to 24 in.	*	150 pounds	150 pounds

*For steam lines larger than 16-in., Crane 150 pound Cast Steel Gate Valves are recommended. (For sizes under 2 in., use Crane Clamp Gate Valves.)

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VALVES · FITTINGS · PIPE
PLUMBING · HEATING · PUMPS

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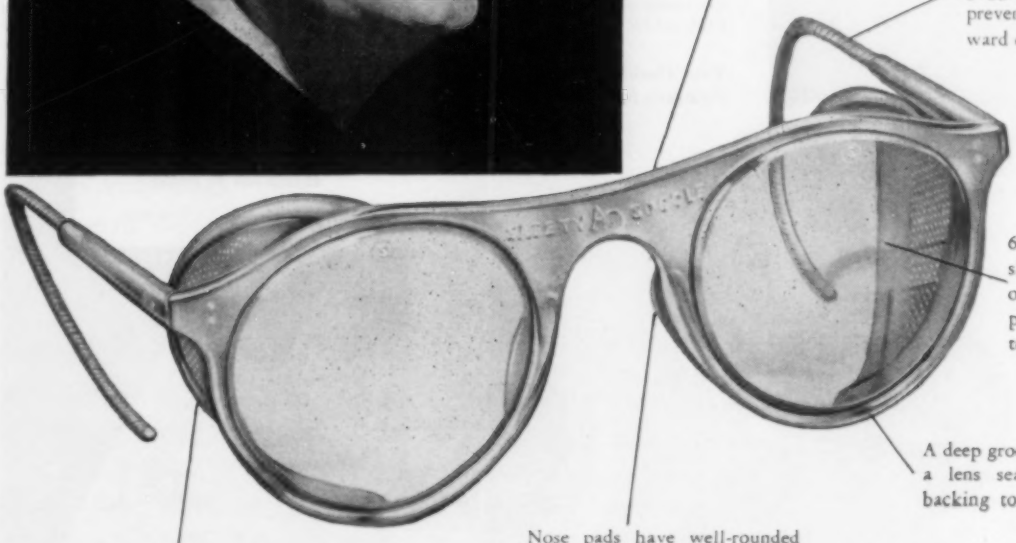
Stronger, more sturdy front than on ordinary acetate frames. Bridge has a slight amount of face form to give added side protection.

Comfort cable temples hold goggles snugly in position—prevent them from sliding forward on nose.



6-curve Super Armorplate lenses shaped to conform to and cover orbit of eye, provide maximum protection and vision, plus better appearance.

A deep groove in lens rim forms a lens seat with substantial backing to resist *severe* impact.

Nose pads have well-rounded edges and ample flare to withstand ordinary jolts and blows.

Acetate side shields protect against particles striking from sides. Perforated to provide ventilation and help keep lenses from fogging.

AO Ful-Vue Acetate Goggles come in three eye sizes and three bridge sizes—made in transparent acetate, with or without side shields, with clear or Calobar 6-curve Super Armorplate lenses. Your nearest AO Representative can supply you. Call him today.

American Optical
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SOUTHBRIDGE, MASSACHUSETTS

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Can Speed Many Surfacing Jobs

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Your Norton abrasive engineer will be glad to give you the specifications for your particular job.

NORTON COMPANY
Worcester 6, Mass.

W-995A

NORTON ABRASIVES

ON THE COVER

THE bomb-bay doors on the Boeing B-29 Superfortress are opened and closed by a pneumatic device which replaces the electrical controls used on B-17 Flying Fortresses. With the older apparatus it takes fifteen seconds to open the doors, and longer to close them. German fighters quickly learned this and lurked out of range until they saw the doors start to open. Knowing that the bomber was then starting its run and would maintain a constant speed and a straight course to give the bombardier an opportunity to track his target accurately, they would close in for the kill. Pilots tried opening the doors at the last second, but this handicapped the bombardier. The Air Technical Service Command asked Boeing to design a better method; and, after several had been tried out, a compressed-air device was selected. It opens the doors in seven-tenths of a second and closes them in three seconds.

•

IN THIS ISSUE

PITTSBURGH and its environs, a leading production area of vital war materials, was confronted with a gas shortage. In order that many plants would not be faced with the necessity of changing over to some other fuel, a 1265-mile pipe line was laid in approximately one year to deliver gas from Texas. The line is described in our first article.

•

THE important aid that optical glass gives our armed services, especially the Navy, and the part that the Bausch & Lomb Optical Company is playing in its production, are covered in an article starting on page 103.

•

A SHORT article describes a new highway that is vital to the economy of Honduras. Another one tells how British sappers rely on pneumatic tools. Interesting applications of compressed air are illustrated and described in a 2-page spread.

CORRECTION

TWO hoists at the Mount Hope Mine, illustrated on page 65 of our March issue, were erroneously described in the caption as being of Lidgerwood make. These are Nordberg hoists, as stated in the text of the article.

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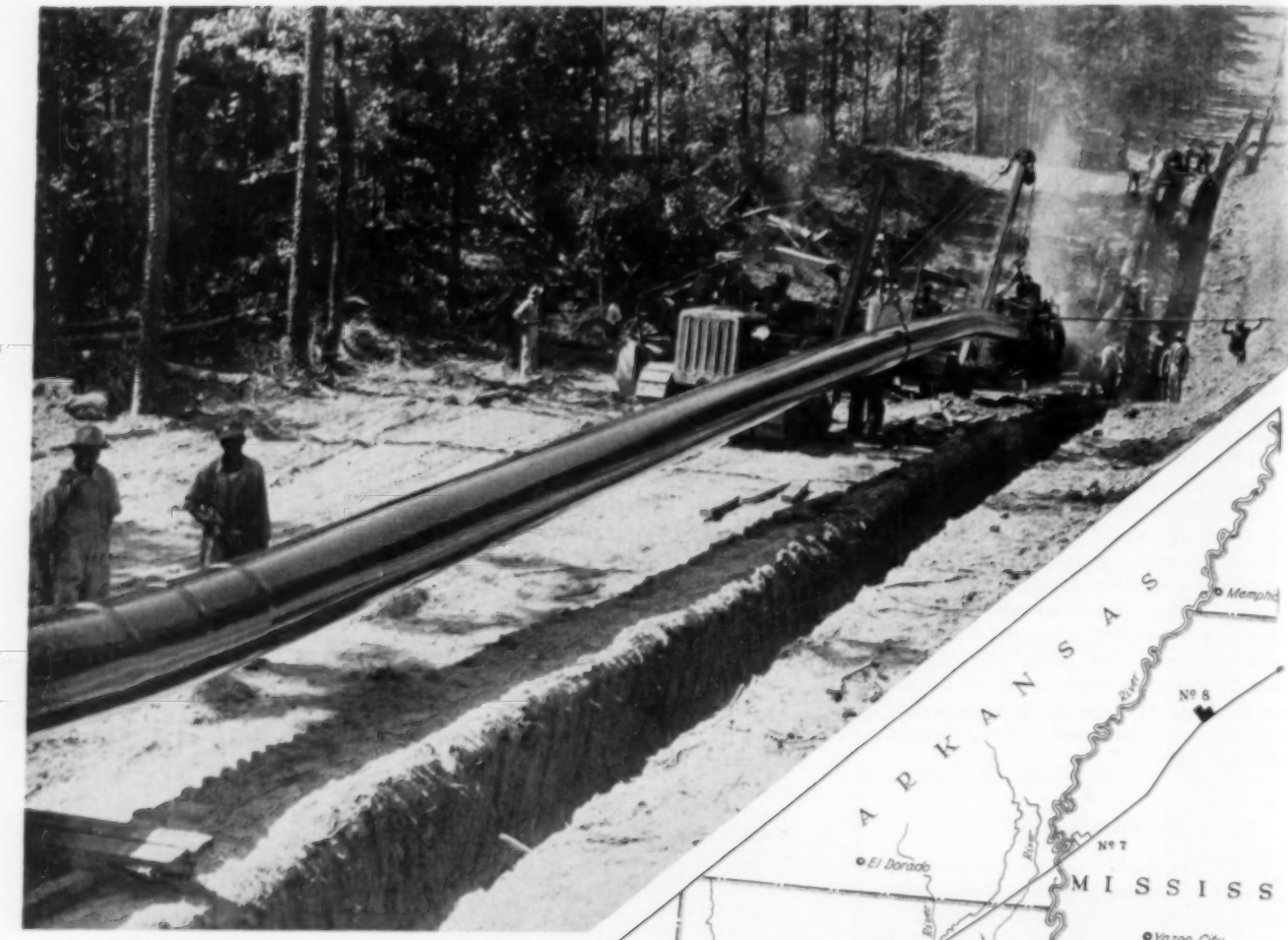
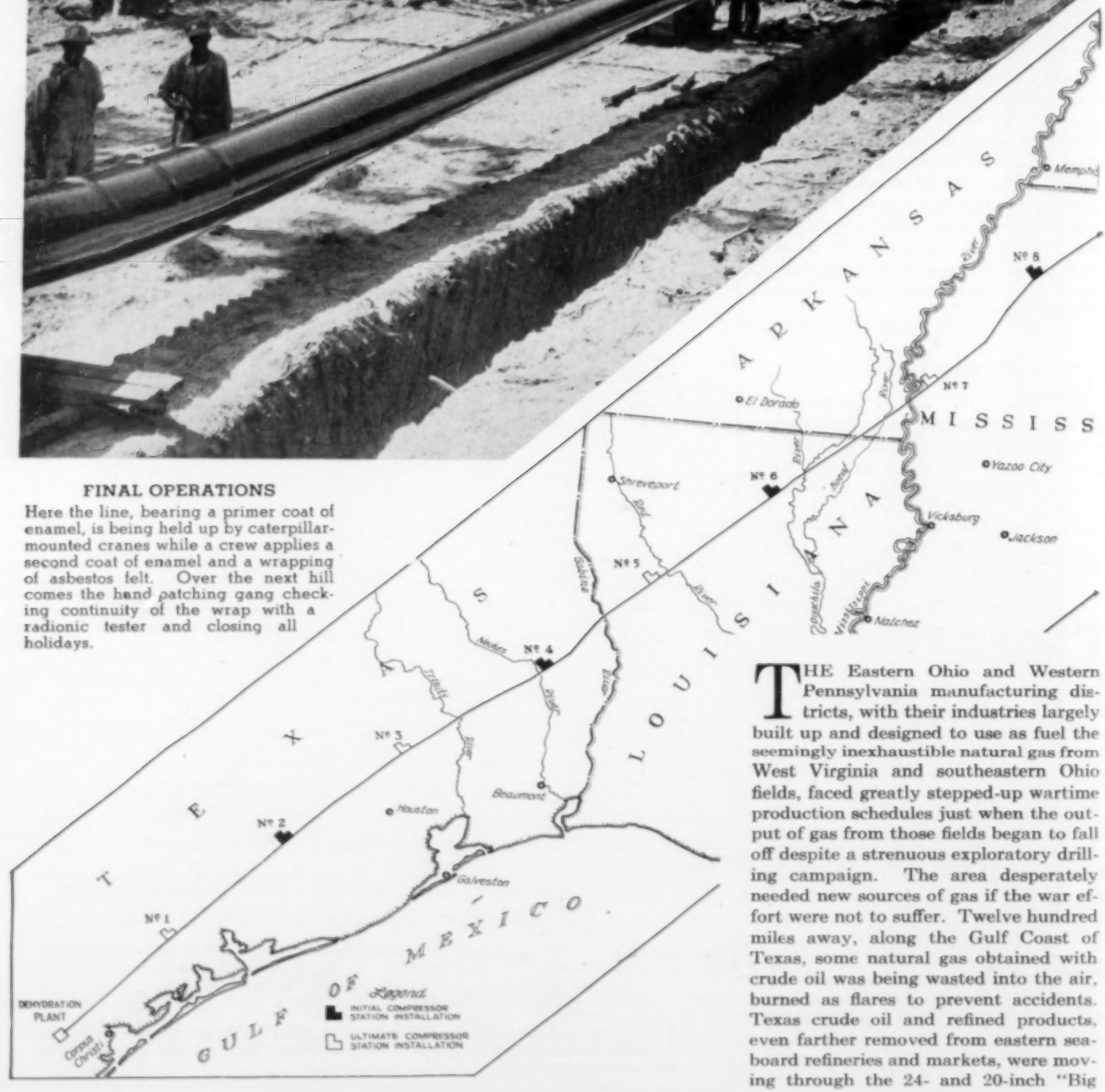
Texas Gas for the Pittsburgh Area



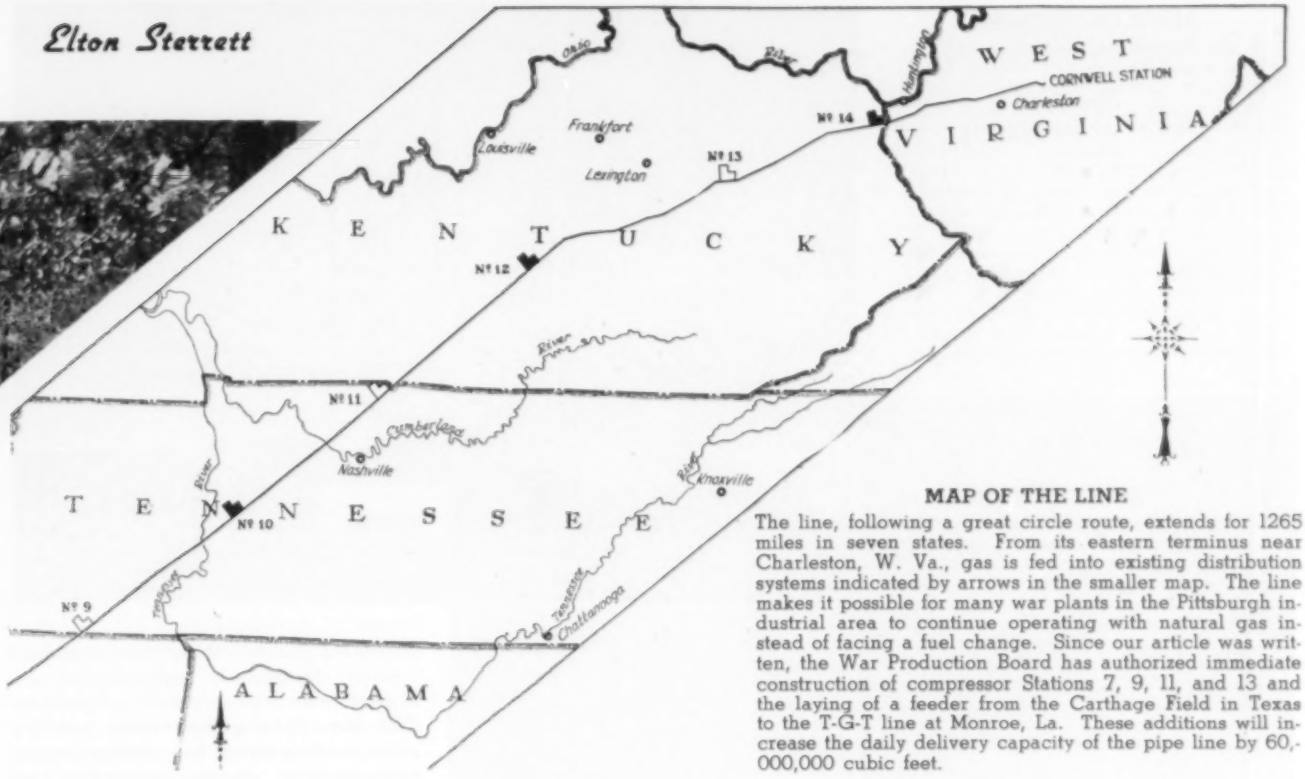
FINAL OPERATIONS

Here the line, bearing a primer coat of enamel, is being held up by caterpillar-mounted cranes while a crew applies a second coat of enamel and a wrapping of asbestos felt. Over the next hill comes the hand patching gang checking continuity of the wrap with a radionic tester and closing all holidays.



THE Eastern Ohio and Western Pennsylvania manufacturing districts, with their industries largely built up and designed to use as fuel the seemingly inexhaustible natural gas from West Virginia and southeastern Ohio fields, faced greatly stepped-up wartime production schedules just when the output of gas from those fields began to fall off despite a strenuous exploratory drilling campaign. The area desperately needed new sources of gas if the war effort were not to suffer. Twelve hundred miles away, along the Gulf Coast of Texas, some natural gas obtained with crude oil was being wasted into the air, burned as flares to prevent accidents. Texas crude oil and refined products, even farther removed from eastern seaboard refineries and markets, were moving through the 24- and 20-inch "Big

Elton Sterrett



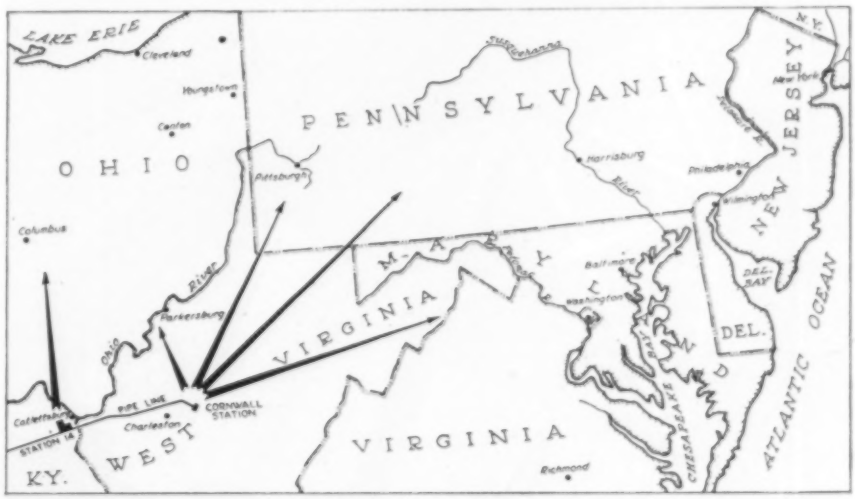
MAP OF THE LINE

The line, following a great circle route, extends for 1265 miles in seven states. From its eastern terminus near Charleston, W. Va., gas is fed into existing distribution systems indicated by arrows in the smaller map. The line makes it possible for many war plants in the Pittsburgh industrial area to continue operating with natural gas instead of facing a fuel change. Since our article was written, the War Production Board has authorized immediate construction of compressor Stations 7, 9, 11, and 13 and the laying of a feeder from the Carthage Field in Texas to the T-G-T line at Monroe, La. These additions will increase the daily delivery capacity of the pipe line by 60,000,000 cubic feet.

Inch" and "Big Inch, Jr.," pipe lines, with their combined throughput of 550,000 barrels per day. Why not another big-inch to bring Texas gas to the fuel-starved industrial area?

The answer is the Tennessee Gas & Transmission Company's 24-inch system extending in a great circle course from the dehydration plant just west of Corpus Christi, Tex., to Cornwell Station, W. Va. It consists of 1180 miles of 24-inch trunk line, with an 85-mile, 20-inch extension to the farther of the two tie-ins with existing gas-distribution systems. Taking over an already formed company with some right of way and distribution permits on September 23, 1943, and retaining the original name (which presaged distribution to Tennessee municipalities), the new operating organization faced the problems of manning, designing, and building 1265 miles of pipe line, erecting seven compressor stations, and delivering gas before the winter of 1944. The sole factor favoring the tremendous project was that it could be laid out complete from scratch. There were no outworn facilities, no old compressor plants or other equipment to be utilized. Only manufacturing restrictions hampered the selection of station and line equipment.

As is common with most wartime developments, the line was designed to handle a certain throughput with a minimum outlay for stations. From an initial 207 million cubic feet per 24-hour day, the capacity was to be boosted to an ultimate 262 million by the construction of intermediate compressor stations. Thus, the present approximate 170-mile



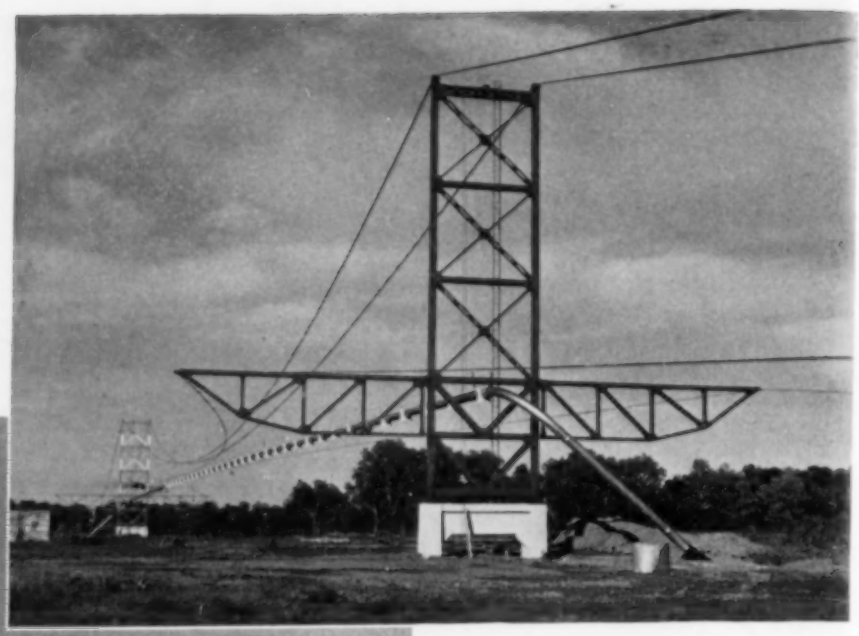
spacing will eventually be halved to place the plants 85 miles apart.

The terrain traversed by the line ranged from flat coastal plains in Texas to nearly liquid swamp areas in Louisiana and Arkansas, rivers such as the Red, Mississippi, Tennessee, and Cumberland, and, finally, mountainous eastern Kentucky. Much of the work involved was expedited by the experience gained on the earlier large oil lines, though the additional depth to which the gas line had to be buried to provide sufficient weight of earth backfill to overcome the buoyancy of the pipe (with only gas for ballast) when the right of way was flooded increased the difficulty of trenching in many areas, especially where rock was encountered.

Some of the contractors cutting the 36-inch by 6-foot trench used two ditching machines to advantage. The first machine, excavating full width and to a depth of 30 inches, removed most of the heavily matted root growth, or left it exposed where axmen could quickly trim it off, and piled up a bank of earth behind which the following machine deposited its spoil, thus preventing clods from rolling back into the ditch. A bottom shaper was another trenching innovation. It consisted of a scoopshaped cutting edge and trailing fingers which broke up and distributed the soil to form a relatively soft bed or mulch onto which the pipe could be lowered. The utilization of mechanical equipment such as back hoes, clamshells, and drag

RIVER CROSSINGS

At the Mississippi River the 24-inch main is divided into two 18-inch lines which are carried, one on each side, across a bridge (below) at Greenville, Miss. The pipes are supported on rollers, each within a rectangular frame, that permit them to move longitudinally as they expand or contract. To lessen the weight, the carrier assemblies are made of aluminum alloy. Six other watercourses are crossed by suspension spans such as the one shown at the right. Some rivers with rocky beds were negotiated by laying the pipe in trenches blasted in the bottom. All told, 67 streams were crossed.



lines for cleaning out after cave-ins and digging bell holes for the welders eliminated the usual never-ending task of trying to find the manpower—the shovel gangs—that generally do this work. In the rocky sections, where drilling and blasting had to be done, compressed-air drills were employed for trenching and for pop-holing boulders which necessitated shots more powerful than 'dobe charges to break them down to handling size.

The pipe laid between stations is 24 inches in outside diameter and has ¼-inch walls with a yield point of 50,000 pounds per square inch. This thin-walled piping required special handling during shipping, unloading, and stringing to prevent crushing or distortion, and presented the principal obstacle to rapid welding of the joints. With the exception of the river crossings and station-yard manifolds, practically all the line within the borders of Texas was pressure-welded. Here was the first use of this new method on pipe larger than 12 inches, or where the ratio of wall thickness to diameter was so small. By it, abutting ends of the already welded line and the next length—mill doubles averaging around 40 feet were standard—were clamped in hydraulically actuated jaws and carefully aligned so that the opposing faces came together evenly all around the circumference. Oxyacetylene torches, or rather one gigantic multiple torch with 365 burner jets, heated the pipe ends until the proper welding temperature was reached. Then, under hydraulic pressure, the free pipe was moved against the joined line and the weld finished. Under normal conditions, one pressure-welding machine and crew could make 100 welds in an 8-hour day, or complete 4000 feet of line. Beyond the crossing of the Sabine River, electric arc welding was used to connect the trunk-line lengths, all station manifolds being arc-welded at the site.

The thin-walled pipe was shaped to conform to the contours of the terrain by cold wrinkle-bending. Clamped in special jaws to prevent deformation of the fixed end, the free end of a length of pipe was pulled through a predetermined arc by means of a back-geared winch and cable until a wrinkle bend formed just ahead of the clamps. Moving the pipe 15 inches through the jaws, a second wrinkle was formed in the same manner, and as many others as necessary to obtain the desired degree of curvature. Wrinkle-bending maintained the full inside diameter of the pipe, made the transition in direction so gradual that no appreciable interference was offered pipe-line scrapers or swabs, and did not reduce the effective thickness of the material at any point. The portable wrinkle-bending machines traveled ahead of the welding spreads, shaping the pipe to follow closely the sags and humps at the bottom of the big ditch.

All highway and railroad embankments were underpassed by piercing a hole through them for 30-inch casing

with a gas-engine-driven auger. This horizontal drilling machine traveled on wooden rails, its forward motion being provided by the winch line of an anchored truck through appropriately placed sheaves. The hole was cut accurately to line, and with minimum clearance for the casing. The latter is 9/16 inch thick, and was arc-welded in the open to form the entire crossing by the firing-line method. When all the sections had been joined, disks of heavy plate were welded on to close the ends, after which an air compressor was connected and a test pressure of 110 pounds built up inside the unit. Soapy water was brushed over all welds and their tightness proved before the assembly was dragged or pushed through the embankment. Then the pipe line itself was run through and the ends were seal-welded to prevent shifting or filling with water and sediment. River-crossing sections also were air-tested to insure against leaks before placing the heavy crossing clamps, wrapping the respective lines with wooden slats to take abrasion, and dragging each across the stream to lie in a trench blasted to a depth of approximately 8 feet in the river bottom.

PRESSURE WELDING

Throughout most of its course in Texas, the 24-inch pipe, only ¼-inch in wall thickness, was welded by the pressure-weld method by which clamps align abutting ends, hold them while they are brought to welding temperature by a gigantic torch with 365 tips, and then force the incandescent ends together under hydraulic pressure to complete the weld.

USES OF AIR

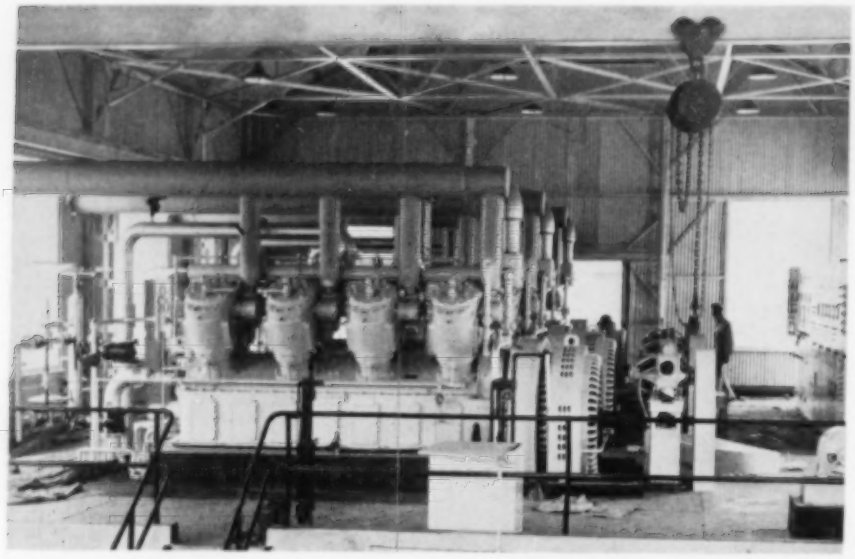
In rocky sections (mostly in Kentucky) rock drills and explosives were required to excavate the trench. On steep hills, tractors moved the portable compressors that supplied the air. The line was carried under railroad crossings in casings that were tested for tightness with compressed air and soapsuds before they were put in place. The welder seen at the right is "sewing on" an end plate preparatory to making the test.

Aerial crossings were provided in the case of many of the larger streams, especially where high banks facilitated spanning the watercourses or where erosion during periodic floods is especially severe. These suspension structures consist mainly of U-shaped pipe saddles held in place by cables. The crossing was effected by welding a joint at a time on a platform on one of the supporting bank towers and shoving or dragging the pipe through the saddles as fast as it was lengthened. Weld clamps stiffened the pipe throughout such sections and provided against possible flexing during construction.

The longest crossing is that over the Red River, in Louisiana, where the main suspension and wind-sway cables have a free span of 1920 feet. The Mississippi was crossed by laying two 18-inch lines on an existing highway bridge, one on each side of the roadway to balance the load. So carefully was the weight reduced that aluminum could be used for the supporting brackets and even for the spindles and spools on which the piping is carried.

To prevent the formation of hydrates at the exposed river crossings and throughout the northern end of the line, even under the most severe winter conditions, the gas is dehydrated to depress the dew point about 50°F. below the incoming temperature. Thus the dew point of the gas will at no time be more than approximately 30° at the outlets of the compressor stations and lower than that as the gas loses pressure between stations. The dehydration plant consists of three contact towers, 78 inches in diameter and with a net shell length of 31 feet 6 inches. Each unit contains two scrubber sections and four contact trays, where the incoming gas is intimately mixed with concentrated diethylene glycol which, being hygroscopic, absorbs moisture from the gas and depresses its dew point. On leaving the contactors, the gas flows through meter runs and thence to pressure reducers where the initial line pressure of 750 pounds per square inch is assured.

The gas coming into the dehydration plant, after being processed in absorption plants for the removal of liquid hydrocarbons, is under a residual well pressure of around 900 pounds. This pressure remains in the gas after completing its cycle through the dehydration equipment and is sufficient to carry it 162.57 miles, at which point there is



GAS-ENGINE-DRIVEN GENERATORS

Electric power for each compressor station is supplied by three Ingersoll-Rand gas-engine-driven generators such as are shown here. The engines are of the V-type and are rated at 370 or 400 hp. Each drives a 250-kw. generator. The current is distributed through a master switchboard with circuits for operating any desired combination of pumps and other auxiliaries.

still ample suction-manifold pressure, under the skip-station plan now followed, for the first battery of compressors in the first unit. This dehydration is the only treatment the gas receives, except passage through dust scrubbers on the incoming side of each station manifold, in its 1265-mile travel. Following contact with the gas, the diethylene glycol is passed through a reboiler and still in order to remove its moisture, and the lean glycol is then recycled through the contactors.

A recording calorimeter and gravitometer are housed in a special building at the dehydration plant. The room has double windows, fully insulated walls and ceilings, and sliding doors to maintain uniform conditions around the instruments. The calorimeter is used to determine the heat value of the gas entering the line, reading directly in gas at 30 inches of mercury and 60°F., saturated. It does all this without manual operation, correction, or calculation. The gravitometer obtains and records, also permanently, the gravity of the gas going into the line. This system gives a continuous and exact reading of the characteristics of the gas handled by the system and eliminates the approximations obtained with only periodic sampling and analysis.

Because war-overloaded facilities precluded any one manufacturer from turning out all the compressors or all of any one type of principal auxiliary machinery, the line, so far as stations are concerned, became in effect two separate systems. The compressors, circulating pumps, motors, auxiliary or power-plant units, and other mechanical equipment in the first three of the initially erected stations are identical, while there is an almost 100 percent change in manufacturers' name plates on the machinery doing parallel duty in the last four stations.

Each of the first three stations has nine 1000-hp. angle-type compressors placed end to end in the 30x304-foot steel building. Selection of this machine, as compared with the older horizontal, opposed type, was in a sense automatic, as the War Production Board ruled in favor of the high-speed angle-type unit on account of its lower weight per horsepower. While this choice was in accordance with the WPB ruling, evaluation of the load requirements of the line would probably have dictated the use of the latter compressor because of its superior economic and operating characteristics. Further, there is a noteworthy saving in the housing of the units. The long, relatively narrow main stations are readily spanned by overhead cranes, present no serious lighting problems, and occupy but little more than half the area needed for horizontal compressors of like capacity.

The last four stations are 36x202 feet in size because the compressors installed there are placed with their crankshafts perpendicular to the axis of the buildings. Stations 8, 10, and 12 each contain eight 1000-hp. V-angle-type compressors, while Station 14 has but seven, one unit being omitted on account of the reduction in over-all gas volume through withdrawals of gas for fuel along the line.

The engine-driven compressors are mounted on deep foundations isolated from the main or operating floor by air gaps. The foundations are carried to a depth which affords an ample basement or cellar, in which are located the gas piping, the lube oil-heat exchangers, oil lines, purifying equipment, and volume cylinders for fuel gas. The basements are fully ventilated and provided with access stairways at each end and with built-in escape ladders at windows along the side. The ladder rungs are U-shaped 1-inch steel rounds cast into the concrete wall, with the windows above them opening outward into pits large enough to permit quick egress in case of emergency.

The engines in the first three stations have two mufflers each, with the exhaust pipes between manifold and muffler jacketed and vented outside so as to carry out the heat radiated by the exhaust lines. A stack, connected to this exhaust annulus, is mounted between muffler and building to assure natural draft for adequate hot-air disposal. Dampers in these stacks provide for retention of part or all this waste heat within the stations during cold weather. Each unit in the last four has a single muffler, with the same arrangement for cooling the exhaust line from the point where it emerges from the water-cooled engine jacket. Sixteen-inch backfire relief valves serve to protect the air cleaners on the 18-inch intake lines to all engines.

At present, and until installation of the intermediate odd-numbered stations, the gas is compressed from about 401 pounds on the suction side to 750 pounds, discharge. In the pipe line, as ultimately completed, these pressures will be 475 pounds and 750 pounds. The compressors in the first three plants have three compression cylinders, each 8¼x15 inches, while the machines in each of the next three have four cylinders, 7½x14 inches. In Station 14 there is a slight variation from this plan to allow for split-stream pressuring for delivery to nearby and distant points. All cylinders are designed with built-in clearance pockets to provide for present and future operation.

All ignition throughout the system is of the direct-current impulse type with an individual induction coil for each spark plug. Instead of using the conventional magneto to furnish energy for the coils, power for each engine is taken from the station alternating-current lines through an individual direct-current rectifier of the copper-oxide type. This system of powering ignition circuits was developed for this pipe line, and was thoroughly tested by the manufacturer before installation. The rectifier draws current from the 440-volt, 3-phase, 60-cycle source, furnishing practically rippleless 12-14 volt, 2-4 ampere direct current.

An important advantage of this method of ignition is the manner in which the entire station is safeguarded

against continued operation in case of failure of station power. Since the water-circulating pumps in all circuits are motor-driven and draw their current from the same source that energizes the rectifiers, it is apparent that shutdown of the generating units would automatically cut off not only the water-circulating systems but the ignition circuits as well. Thus the station would go off the line without delay in case of electric-power failure, and overheating of the compressors would be impossible. Restarting of the plant would be possible only when current had been restored.

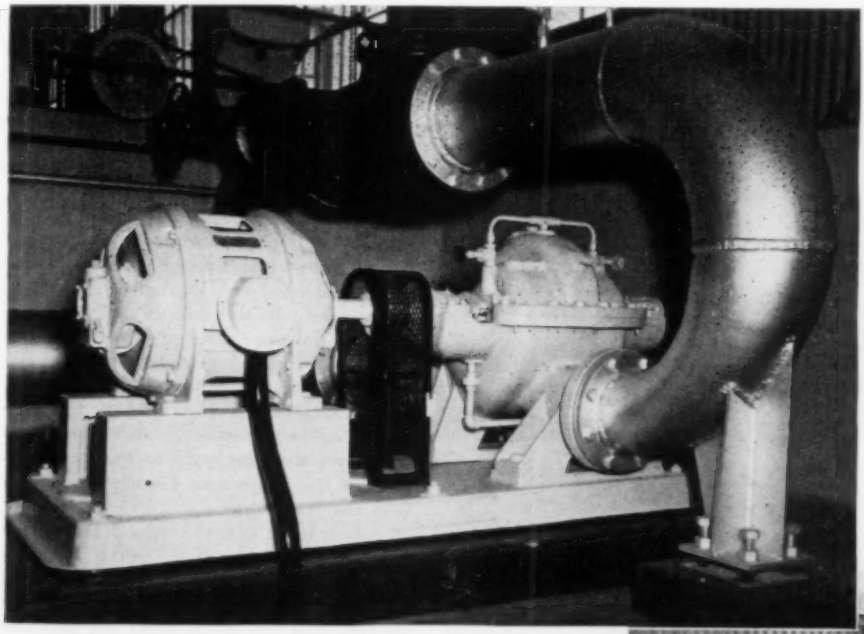
Two oil-reclaiming units are located in the basement of each station. Piping and interlocking valves permit the oil to be drawn from the sump, treated, and returned to any given engine in the station so as to prevent the inadvertent draining of oil from one engine and returning it to another. Gravity flow from the crankcase of the engine to the reclaiming unit or the dirty-oil storage tank makes for closed-system conveying of all oil, without need of handling on the operating floor. When an engine is taken off duty for maintenance, the crankcase oil is drained to the dirty-oil tank and held there until the unit is again ready for service, when the oil is put through the reclaimer and piped directly to it. Manually operated dispenser pumps at both ends of the station draw oil from the clean tank, while other manual pumps located midway of the station length are connected to the oil-storage system in the yard, where an elevated tank, with a capacity of 4000 gallons of lubricant, permits flow to the dispenser units by gravity.

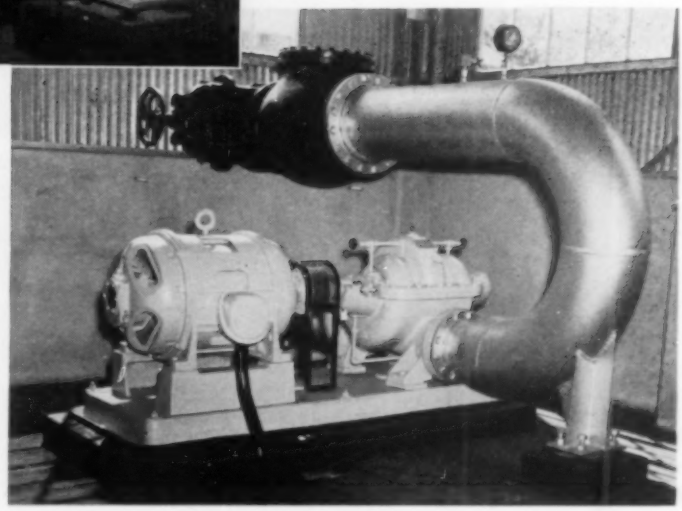
Gas at line discharge pressures goes through a 24-inch manifold system to one part of a cooling tower where it passes through atmospheric cooling sections before being admitted to the outgoing line. These sections consist of straight tubes between headers and are designed to keep the pressure drop low. Each is provided with 8-inch inlet and outlet nozzles, both lines being fitted with quick-operating block gates to permit isolation for maintenance or in case of diminished throughput.

The cooling towers are of the induced-draft type, circulating 8000 gallons of water per minute for spray purposes in each of the first three stations, 8960 in the next three, and 9450 in the last. The average basin-water temperature is estimated to be around 92°F., with the water cooled to 80° when the wet-bulb thermometric reading is 75°. Three pumps, electrically driven and equipped with dual suction screens, circulate the basin water through 24-inch header lines from which water is taken over the towers in three 16-inch distribution mains provided with orifice plates for metering. Make-up water is added through a 4-inch line with a metering run so that constant wastage may be maintained to control the percentage of salts present in the water.

Cooling water for the compressors is divided into two circuits, designated as "hot" and "cold," because of relative temperatures. The hot circuit feeds water in parallel through the engine cylinder jackets, as well as through those of the engines driving the electric-generators, which will be described later. Thence it passes through cooling sections in the tower. The entering water is held at 140°F., and the temperature rise is 10°. Circulation is effected by means of two horizontal, single-stage centrifugal pumps, each rated at 3600 gpm. A 10x20-foot vertical surge tank is interposed in the suction lines of these pumps to insure a full system. Two pumps normally handle this hot circuit, with a third installed as a standby.

The cold system forces water through the oil coolers and compressor cylinder jackets in series. From there it flows to a 4x20-foot vertical surge and vent tank, which is mounted over the suction manifold. In the first three stations circulation is maintained with a single-stage,





COOLING-WATER PUMPS

There are two cooling-water circuits in the compressor stations designated as "hot" and "cold" because they are of different temperatures. In the case of the hot circuit, water flows in parallel through the jackets of the cylinders of the engines driving the compressors and those driving the generators. It then passes through a cooling tower. The cold circuit flows to the cooling tower by way of lubricating oil coolers and the compressor cylinder jackets. Treated water is used in both systems, there being 45,000 gallons in the hot and 15,000 gallons in the cold circuit. Two centrifugal pumps normally handle the hot system and one the cold circuit, with a spare provided in each case. Shown at the right is an Ingersoll-Rand 3600-gpm. hot-circuit pump and, above, a similar 1335-gpm. unit in the cold circuit. The support under the reverse bend in each discharge line relieves the pump of overhanging load. The weight is borne on four hardened ball points, on adjusting screws, which are free to move across a supporting plate as the pipe expands or contracts.

horizontal, double-suction centrifugal pump having a capacity of 1335 gpm. The other four stations have similar equipment, but the rated capacity is 1850 gpm. Spare pumps are installed.

All water is treated to prevent corrosion and to lessen scale-forming tendencies. The cooling tower and basin contain about 175,000 gallons, the hot system another 45,000 gallons, and the cold circuit some 15,000 gallons. A 2000-barrel tank provides storage for the raw supply as delivered from nearby streams or from wells in the station yard, while an elevated tank furnishes water for fire protection and sanitary use.

Each of the seven compressor stations as now built has its own power-generating equipment—is independent of utilities. The electric plant in each of the first three stations consists of three 400-hp., 4-cycle gas engines driving direct-connected generators at 450 rpm. The engines in the last four stations develop 370 hp. at 400 rpm. Standard, open-frame-type generators are installed throughout. They are rated at 312 kva., 250-kw., 480-volt, 3-phase, 60 cycles, with a 104°F. rise and are individually equipped with V-belt-driven exciters. These generators feed electric energy direct to a totally inclosed control center which includes breakers for the various pump circuits, air compressors, water- and cooling-tower pumps, compressor ignition, and lighting needs.

SOME DETAILS OF THE SYSTEM

Pipe Line			
Outside diameter, inches	24	24	20
Wall thickness, inches	9/32	¼	9/32
Miles	300	880	85
Minimum yield point, pounds	45,000	50,000	45,000
Minimum tensile strength, pounds	70,000	70,000	70,000
Bursting pressure, pounds	1,641	1,458	1,968
Yield pressure, pounds	1,055	1,042	1,265
Safety factor on yield point	1.4	1.39	1.67
Safety factor on tensile strength	2.19	1.95	2.62
Pipe, weight per mile of line, tons	188.1	167.41	156.37
Pressures			
Maximum operating pressure, 24-inch	750 psi. gauge		
Terminus pressure	475 " "		
Compressor station suction pressure	400 " "		
Compressor station discharge pressure	750 " "		
Daily Capacity			
Initial design, cubic feet	207,000,000		
Ultimate design, cubic feet	262,000,000		

Each power station has two starting-air compressors, one being motor-driven and the other, simply by changing V-belts, being operated by an electric motor when station-generated current is available or by a 4-cylinder gas engine. The latter is manually started and provided with an ignition system that is independent of the power developed locally.

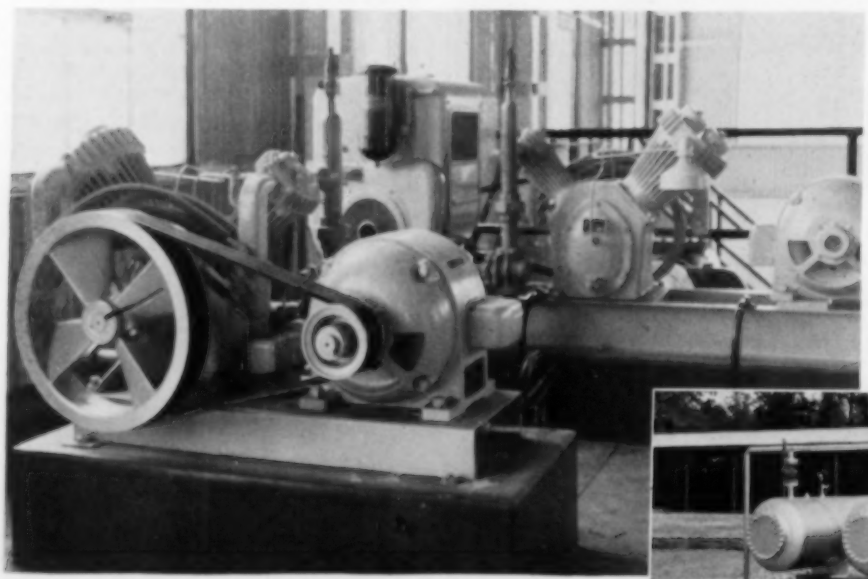
Fuel-gas for the prime movers is taken from the 400-pound-pressure supply entering the yard. A regulator cuts this pressure to 200 pounds, whence the gas flows through a second regulator which lowers the pressure to 45 pounds. The latter unit is duplicated to provide a standby, either one being sufficient to handle the full fuel requirements throughout the designated pressure range. From the second regulator the gas enters a volume chamber, passes through a metering run with a standard orifice plate, and then goes into a second volume chamber equipped with a balanced pressure-regulating valve through which the station is supplied. The pressure is further reduced from 45 pounds to 1 pound, and then from 1 pound to 3 inches of water in another volume chamber, whence it enters the engine mixing valve.

With the first main-line weld made on January 10, 1944, within 3½ months of the company's formation, the final weld was completed on October 29, just 293 days later. Initial delivery of gas, carried at line operating pressure right up to the last block gate downstream of the final weld, was started on October 31.

The excellent records achieved in pipe laying and compressor-station construction were due not only to the organization of the Tennessee Gas & Transmission Company but also to the fine spirit of coöperation and willingness to assume extra burdens exhibited alike by contractors on the job and manufacturers of the equipment. Just one year, one month, and one week from the day the undertaking took corporate form, badly needed Texas natural gas was helping to fuel the industrial plants on whose output depends so much of the timing of ultimate victory.

ENGINE-STARTING UNITS

Compressed air at 250 pounds pressure for starting the gas engines that drive the main compressors and the generators in each station is furnished by Ingersoll-Rand air-cooled compressors. The unit at the left is motor-driven, while the one in the background can be operated by either a gas engine or a motor. The compressors discharge into four horizontal outdoor receivers, each 2½x15 feet in size, and from the latter run supply lines to the buildings that house the engines. The air tanks are manifolded to both incoming and outgoing air lines, and block gates permit isolating any tank for repair or cleaning.



The Eyes of Warfare

Robert G. Skerrett

Official U. S. Navy photos pages 103-6

GETTING THE RANGE

The seaman at his station alongside a rangefinder on an aircraft carrier is in constant touch by telephone with the ship's control room. Similar rangefinders determine how the 16-inch guns on a battleship should be pointed and elevated to hit a distant target.

IT MAY be comforting to know that we have the world's largest combat fleet and that all those fighting craft carry armaments capable of doing much damage—as well our enemies know by now. But today, as in the years gone, only the shots that hit are the ones that count.

Wonderful battle giants as many of these ships are, they would be the victims of dim sight if they had to depend wholly upon the range and clarity of unaided human vision to measure forces with an alert foe. Indeed, they would more often than otherwise be scarcely better than the most skillful of fencers forced to fight with his eyes screened by a thick veil. Something has to be done to bring the sight of the personnel to a perceptive keenness befitting the very long ranges at which our large naval guns can strike with tremendous effect. Battle craft must be prepared to engage an enemy, night or day, under a wide range of atmospheric conditions, and perhaps with visibility even further impaired by an artfully laid smoke screen.

It is not generally known to what extent good shooting depends upon amplification of the vision of even the best of normal eyes by artificial aids. This was pointed out by the late Rear Admiral Bradley A. Fiske, U.S.N., who gave us our first optical rangefinder in 1890 and to whose inventive mind the Navy was indebted for the first of its telescopic gunsights. That eminent officer said to a congressional naval committee in 1916: "The problem in gunnery—most people do not realize it— is not so much a gunnery problem as it is an optical problem." And he told that the ordinary sights in service along in the early 90's, when ranges did not exceed 2000 yards, imposed a heavy tax on the gun pointers and that the shooting often was bad. Continuing, he explained: "Now, a telescope of large field and small magnification has been found to practically eliminate all the errors of sighting, and to make it possible and easy for an ordinary man with hardly any practice at all to shoot fairly well always, and badly never."

The manufacture of optical instruments has for many decades been an established industry in this country, but for our optical glass we had to turn entirely to Europe until just before World War I. Then we were confronted with the fact that our imports were rapidly reaching the vanishing point and that no more of that glass could be obtained from abroad. When our participation in the

AIRCRAFT INSTRUMENTS

The rear-seat gunner in a carrier plane (right) looks through goggles and an optical sight as he brings his twin guns to bear against the enemy. Reconnaissance planes use a 40-inch telephoto lens for high-altitude photography (above).

conflict became certain, we had to find ways to make it ourselves so as to equip the nation's fighting forces.

As a people, we have been so busy with other things during the intervening years that all too few of us know how desperate was the situation shortly before we declared war on Germany on April 6, 1917. Dr. Arthur Louis Day was at that time Director of the Geophysical Laboratory of the Carnegie Institution, and in 1933 he told the story of how we were able to meet the test despite the newness and the magnitude of the demand made upon our glass industry. That scientist had a prime part to play in dealing with the crisis, and with a group of about twenty associates met in Washington in March of 1917 to have military men disclose to them our unpreparedness in the matter of field glasses, gunsights, rangefinders, periscopes, and other optical instruments. The Navy was in much the same predicament. Optical instruments meant optical glass, which is by far the most refined and also the most exacting product of the glassmaker's art.

Fortunately, among our manufacturers of optical products was one that anticipated the penalty we might have to pay if we continued to depend upon foreign sources of supply. That was the Bausch & Lomb Optical Company which, as a matter of business security, foresaw the need of making itself self-sufficient by learning how to produce its own optical glass—then a closely guarded business in England, France, and Germany. William Bausch, at that time the firm's vice-president, had begun experimenting as early as 1903. In 1912 he constructed a small plant and attempted to make acceptable glass and, that accomplished, to solve some of the secrets so long confined to a few foreign workers. A fire destroyed the place before much was achieved, and it was not until 1914 that it was rebuilt and research resumed. The second effort was decidedly fruitful, and in 1915 the plant turned out a few kinds of optical glass capable of meeting exacting standards. However, the output at best did not exceed 2000 pounds a month, and the estimated requirements of the War Department called for all of 2000 pounds a day! How was the complex problem to be met?

Even for the manufacture of certain fine grades of glass American producers had had to import clays from Germany for making the pots in which the ingredients were melted. One of the clays' prerequisites was that they should be low in iron content lest the molten glass absorb some of the metal, for iron in excess of a very small percentage was known to impair its transparency. Let us make this plain. Ordinarily, during the melting process the intensely hot glass solution tends to corrode the inside of the pot, and in so soing some of the clay and its contained iron is carried into the solution.

We were unaware at that time that this country has deposits of clay of the purity necessary for the manufacture of optical glass, which demands clay of an even lower iron content than does the high-grade glass just mentioned. The first step, therefore, was to find domestic sources of supply. The job was put up to the U. S. Bureau of Standards which, after diligent searching, discovered several areas where satisfactory clays were located. We were moving ahead; but the task still remained a very hard and pressing one, as Doctor Day made clear when he said: "For the optical instruments required by the Government to control its gunfire on the sea and at the front, nine different varieties of optical glass were necessary, and but two of these had been successfully made in this country at any time—the seven others remained shrouded in mystery."

ON THE ALERT

Eyes glued to telescopes or binoculars keep constant vigil at various observation points on naval vessels when they are in hostile waters. Some of the instruments are mounted so that they automatically register distance and altitude of objects sighted.

To deal with the industrial battle involved, the several governmental bodies handling our war needs called to their aid a number of scientists versed in silicate chemistry but unacquainted with the making of optical glass. Two composite groups were formed: one from the Carnegie Geophysical Laboratory in Washington, D. C., that associated itself with the Bausch & Lomb Optical Company in an effort to extend and to perfect that concern's output, while the other from the Bureau of Standards was to operate in part in the bureau's own laboratory in Pittsburgh, Pa., and in part in the Charleroi plant of the Pittsburgh Plate Glass Company. Each group was called upon to help in making one half of the glass needed by both the Army and the Navy.

At the end of four months, Bausch & Lomb had succeeded in turning out its quota and had increased its prewar monthly production fourfold. By the end of 1917 its output had reached 40,000 pounds a month and consisted of the desired quantity of each of the different kinds of optical glass required. And then, early in 1918, the War Industries Board came into being vested with ample power to apply pressure wherever it deemed such action essential to waging war. Here it was where aircraft stepped into the picture to add to the problem of making optical glass.

By that time the airplane was disclosing its value in many ways, and one of them was as a base for taking photographs over enemy lines so as to map hostile country and to aid in planning how and where best to attack. Cameras with unusually high precision and wide optical fields were urgently wanted, as well as lenses incorporating elements having far more exacting characteristics than those of the optical glasses already developed by us. Here was another emergency, and Doctor Day tells the story of what happened: "The time was critical, the pressure high, and the need insistent. The situation was brought to the attention of Edward Bausch—older brother of William—and his group, with the simple statement that it must somehow be done. Mr. Bausch asked no questions and considered no details; his reply was simply that if it could be done he would do it. It proved to be the hardest task yet encountered. The glass was a barium glass, thin as water when melted, and totally different in its behavior from any glass hitherto attempted. It soaked into the melting pots like coffee into a lump of sugar and ran out through the sides. In every detail it required different treatment from the glasses thus far developed. Nevertheless, it was successfully made in four weeks' time, and it saw service at the front."

But Bausch & Lomb was still to have

UNDERWATER VISION

Through the two periscopes of a submarine, human sight is transferred above the water's surface. The picture at the right shows the control-room below deck with an officer at one of the instruments and men at their operating stations.

another task assigned to it—to double its production in 30 days! When asked to do so by Doctor Day, Edward Bausch made no direct answer. He took a piece of chalk, led his visitor to the glass plant, marked on the floor vacant spaces that could be utilized for additional furnaces, and then gave orders for their immediate building. Not a moment was lost. It was just one more display of that spirit of American enterprise that is undaunted by obstacles. Our plants during World War I made 650,000 pounds of optical glass for the Army and the Navy, and of that quantity 450,000 pounds was manufactured under the direction of Edward Bausch and his associates.

The dismaying odds against us in 1917 in this special branch of the glass industry and the technical difficulties that had to be overcome should have taught us never again to let ourselves become dependent upon foreign supplies of optical glass. Although six American companies were engaged in that field at the close of 1918, it is an astonishing fact that only two of them were operating ten years later. One of them was Bausch & Lomb which, prior to the attack on Pearl Harbor, had an output of about 35,000 pounds a month. Since that date production has been as high as 180,000 pounds a month, after deducting the large quantity that is scrapped in turning out the relatively small percentage of usable optical glass per pot.

Before describing how optical glass is made by that company, it will be easier for us to evaluate the service it renders our fighting ships if we detail some of the diversified uses to which it is put, and all because nature has not seen fit to give us as much in the way of sight as in hearing. Strictly normal sight, to put it popularly, has a range of but one octave, while normal hearing can distinguish sound throughout eleven octaves. We see most or best by daylight, and yet a great many of the deciding sea fights of the present war have taken place at night or in regions where low visibility is frequent or where the noonday is short and scarcely brighter than the promise of a dawn.

Optical glass and optical instruments —many of them that we cannot now describe—have been devised and perfected so that the men responsible for firing our guns, launching torpedoes, projecting depth bombs, detecting the enemy and keeping in touch with him at present-day speeds, and for navigating our battle craft under conditions such as may be encountered in the open sea, can get the edge on our foe. The direction of all these operations is grouped under the single classification of "fire control," and some years ago the Navy made public just what this entails.

"Fire control, as understood in naval services, includes the entire system of directing the operation of the offensive weapons of a vessel, including material, personnel, methods, and organization. Its proper development and use is a factor of greatest importance to a ship or fleet. When two or more ships are in action, both will ordinarily be underway and constantly changing course, speed, or both. The problem, then, is for the ship to obtain and constantly keep the correct range of the enemy vessel, and it is the duty of the Fire-Control Section to provide instruments for finding the range, for automatically tracking the enemy, for transmitting such information by electrical means throughout the ship, and to provide the telescopes at the guns." Plainly, this is a highly complex system and very different from some of the kindred burdens laid on the shoulders of a coast-artillery force planted on stable ground. The vessel may roll and pitch, and the observer is moved through a wider sweep and at greater speed as his height above sea level increases.

Every battleship or other large combat vessel is provided with a fire-control station as high aloft as practicable so as to have the advantages of an expansive view of the horizon and of being above low-lying haze and removed from closeness to the blinding flash of the guns. From that position, observers or spotters, thoroughly trained for their important duties, are able to scan the skies and the sea and to pick up and trail hostile craft, to determine their locations and the courses they are following, and to send this vital information to a control room in a protected part of the ship from which directions are automatically transmitted to the firing stations. The men there watch the moving hands of dials that mark how the guns are to be swung horizontally and also elevated to keep them pointed at the enemy vessel so that the projectiles will speed on their arching flights to that distant objective. The handling of antiaircraft batteries is likewise under fire control. Many of the men aloft, and likewise those behind gun shields, wear goggles of special glass that minimize the effects of glare on the water and make it possible for them to gaze directly at the sun in the ordinarily blinding path along which hostile airmen seek to approach their targets.

Optical rangefinders as we have them

now are remarkably accurate, and in one form or another are found on all our battle craft. They operate on the basic principle of surveying instruments, and are designed to measure distances and, in the case of airplanes, particularly heights. The two principal types are the coincidence and the stereoscopic rangefinder, and in either case the length of the apparatus—other things being equal—is the controlling factor as to accuracy. Those aboard our fighting ships have lengths of from 3 feet to more than 40 feet—many are 15 feet, and with the longer instruments one is able, it is said, to measure angles to a closeness of less than half a second of arc!

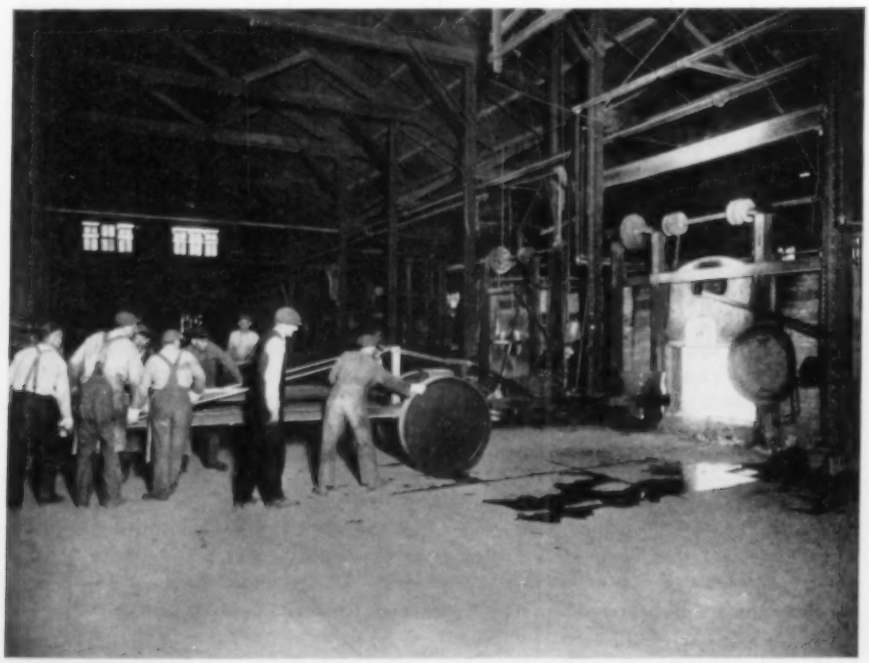
In the coincidence rangefinder the observer first sees a split image, and when he has made the proper adjustments the two parts are brought together in normal conformity. The stereoscopic type simulates the action of our eyes that view an object from two points less than 3 inches apart, and the image has depth or three dimensions when merged and transmitted by the optic nerve to the brain. With a spread of feet between its two magnifying objectives, the latter rangefinder improves proportionately upon our vision, and when those two artificial eyes are brought to bear on a remote target they bring the image to the bifocal eyepieces with all practical clearness and against an etched scale that enables the observer to gauge the intervening distance either on the water or in the sky. The stereoscopic rangefinders that are now produced by Bausch & Lomb are the climax of much research. Marvels of workmanship and refinement that they are, with lenses and prisms of the finest of special glasses, still they have to be sufficiently rugged to withstand not only exposure to the weather but even close proximity to the racking vibrations of the largest of the thundering guns.

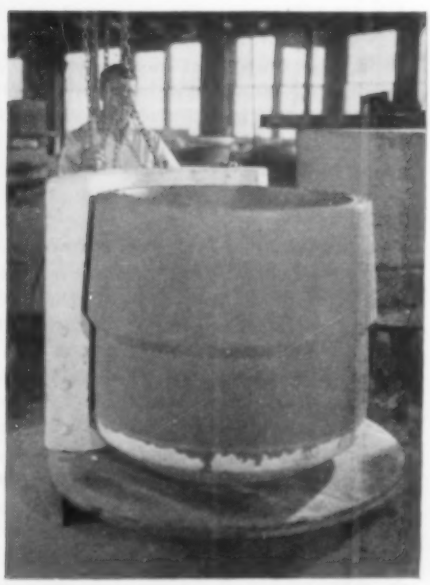
The optical instruments that further the purposes of our fighting ships are also wonderfully effective after nightfall. The records of the current war are filled with examples of magnificent shooting in the hours of darkness and under conditions that not so long ago were deemed either too hazardous or prohibitive of telling combat operations. The star shells that are now fired to illumine a hostile target discount the gloom of the darkest night; and our powerful searchlights, equipped with reflectors of optical glass, can be swung to bear upon the enemy by remote control, flashed long enough to aid the gun pointers, and then dimmed quickly so as to give a minimum of aid to the foe.

Enough is known about our submarines to recognize the handicaps under which they work, but wonderment remains as to just how they have been so successful in the Pacific and when venturing into the home waters of Japan to increase their score. Much of what they have accomplished is attributable to the efficiency of their periscopes. Each vessel is fitted with two of these instruments which, under many circumstances, are truly the submarine's eyes. They are used for navigation, searching, fire-control services, telescopic vision, getting the range of the enemy, determining his speed and line of advance, and for estimating the path a torpedo will have to take to intercept the foe at the end of the "tin fish's" run. When making these observations and rapid calculations, the commander of the underwater boat is possibly in the control room 40 feet below water; but thanks to the ingeniously arranged prisms and lenses, of which there may be a score or more, he can see well-nigh as clearly as if he were above water and standing on the bridge atop the conning tower. And his periscopes, mark you, have to be watertight when subjected to a pressure of 100 pounds per square inch and rigid enough to hold their upright positions when the craft is driving forward at something like 10 knots an hour.

Photoreconnaissance with the aid of the airplane has been invaluable in forewarning our fighting forces about enemy dispositions and giving them other information about the areas to be attacked. Cameras equipped with 40-inch telephoto lenses are capable of doing remarkable work from high altitudes. It is said that the Metrogon, a Bausch & Lomb product, "is so free from distortion that equal areas from any part of the negative can be considered to represent equal areas on the ground." Definition is so keen that a plane can be 3 to 5 miles away from the target horizontally, therefore relatively safe from ground fire, and yet take pictures that can be enlarged to show the minutest detail. The deep curved lenses required are paper thin at their edges and represent the lens maker's skill at its climacteric stage.

It is optical glass that enables the navigator on shipboard to sweep the horizon night or day not only to detect an enemy's approach but to make a landfall by determining his precise location in relation to some given objective. Here is where the seafarer's modern





Bausch & Lomb photos pages 107-9

GLASS-MELTING POT

The melting pot is as important in optical glass making as any other single factor. At the right is a pot with the mold nearly stripped from it; at the left, a pot filled with glass-forming ingredients is being moved into the furnace for melting at high temperature.

OUT OF THE FURNACE

A pot of optical glass after cooling (below) with an arrow pointing to the clay ferrule that was fitted to the end of the hollow, water-cooled stirring rod. Details of the vital stirring procedure were closely guarded secrets of European glass specialists for many years. As the glass cools, it fractures, as shown at the left. Only about one-fourth of the product of a pot can be used for optical purposes.

telescope and that handiest of optical aids the binocular supplement the observer's naked eyes and give him a range that may be anywhere from four to twenty times the magnification of his normal vision. Only optical glass of the highest quality will do for binoculars for our fighting men, and there are numerous exquisitely ground and polished pieces of glass in the get-up of the lenses and prisms required for each of them.

Many of us have wondered how the airman, thousands of feet aloft, is able to find his way back to his mothering flattop or to some base on a small island in an ocean waste. The answer is, he relies on instruments developed especially for him, and one of these is the remarkably efficient bubble sextant. This is an ingenious optical evolution of the conventional marine sextant with which the seafarer "shoots the sun"—measures the altitude, generally at noon, above the visible horizon. The navigator of a plane, on the other hand, is not only high aloft but he is moving at great speed, and the terrestrial horizon is of little if any assistance to him, especially during night flights. Therefore, whether the sun or a star serve his purpose, he must make his observations quickly, preferably a number of them in rapid succession, and average the results. This he can do with his new sextant, in which the bubble is free to move and to level itself in relation to the field of the telescope that is pointed toward the celestial body, thus establishing a horizon from which to measure the altitude of that body.

There was a time when the eyes of the fighting man had to be self-sufficient. Today a large amount of ophthalmic glass is manufactured to correct deficiencies in vision and to enable members of various branches of our Navy to do their work better than they could if they had to depend on normal sight alone. This is notably the case with airmen who have to carry on under dazzling as well as dim-light conditions that necessitate special glasses to protect the eyes and at the same time enhance vision. Before the outbreak of the present war, Bausch & Lomb made some 40 kinds of optical glass, exclusive of colored glasses. Since then the company has developed twelve additional types, and six or eight are in process of being perfected. Because of the involved nature of optics, the optical characteristics of different kinds of glasses, and the physical actions of lenses and prisms of various forms, it is not the intention to explain these many interrelated technicalities. Instead, the remainder of this article will just outline some of the high points of the work that goes on in that division of the company's plant in Rochester where optical glasses originate. But two facts should be kept continually in mind: namely, that the purity of all the ingredients entering into a batch must be of a high degree and that virtually every ingredient affects in one way or another the optical properties of the glass.

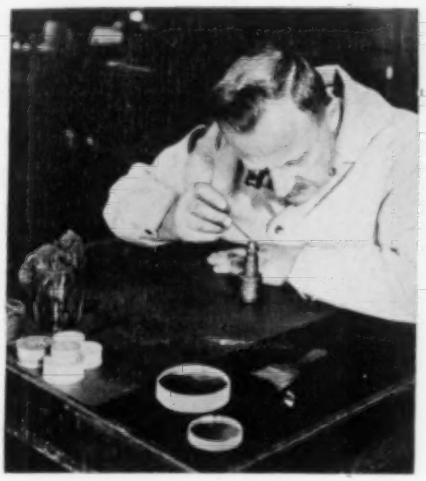
Two broad classes of glass are turned out in the plant: glass for use in optical instruments and distinguished as optical glass, and glass for ophthalmic purposes —eyeglass lenses. The production of the pots may rightly be called the first step in the work. They are made from carefully selected and prepared clays and in accordance with precisely determined formulae. The water content is about 15 percent, and after the materials have been blended for five hours in a blunging machine the mixture is chuted down to the floor below where the molds are set up in which the pots are cast.

The molds are of plaster of Paris and consist of several sections, held together with straps, and of a cylindrical core, also of plaster of Paris, suspended in the mold. After 24 hours the sides are removed, while the core is lifted out when the clay has set sufficiently. The pot is left standing on the bottom of the mold for four days, during which it undergoes air-drying and becomes firm enough to be removed. Then it is placed in storage for from two to three months to dry out under atmospheric conditions, this range of time providing for seasonal variations of the air. The same clay mixtures used for the pots are employed in fashioning the ferrule or "thimble" that is fitted to the rod with which the molten glass is stirred while in the melting furnace. The pots now utilized by Bausch & Lomb contain little iron, with the result that the glasses made in them have an iron content not in excess of 0.017 percent, which is outstandingly low, and have remarkable transparency.

Before a pot is charged, it is preheated to 1800°F. by exposing it directly to hot gases in an arched-roof furnace the door of which is operated with compressed air because it has to be opened and closed frequently. Next, the pot is shifted quickly to a regenerative furnace where it becomes incandescent by radiated heat. When it has reached the glowing stage, the materials are placed in it with a moderate-sized ladle the handles of which are cooled by circulating water. The object in loading a pot piecemeal is to promote uniform penetration of the heat throughout the batch as it is built up. During the melting process, "dips" and "proofs" are made at intervals. The

FINISHING OPERATIONS

Rough glass blanks, after heating and softening (right) are pressed to initial curvature and shape before being ground into lenses. The lens of a small microscope is ground (below) to an accuracy of two-millionths of an inch. Only an expert can do it, and only the finest glass warrants such treatment.



dips show the melting stage, and the proofs disclose how the glass is "fining" —freeing itself of bubbles, and when it is approaching the pouring stage. Experts are depended upon to evaluate what the proofs and dips indicate.

How to stir optical glass during melting was long a closely guarded secret abroad, for upon the thoroughness and length of time and speed of that motor-driven operation hinges the perfection of the glass and the proportion of each batch that will be fit for optical use. Mention has already been made of the clay ferrule on the stirring rod, which is actuated by a small motor working at low speed. The ferrule can withstand the heat and introduces no impurities, while the rod is cooled by water—cold water entering it through one pipe while the heated water leaves by another.

The pots used are of three sizes—30, 36, and 42 inches in diameter, respectively, and the contents weigh about 500, 900, and 1700 pounds. The furnaces are fired with gas from the city mains, and the heat is controlled by optical and recording pyrometers—the maximum melting temperature being 2650°F. The fuel gas is mixed with preheated air to make it burn with greater uniformity and effectiveness. When a pot of ophthalmic glass is withdrawn from a furnace, the molten mass is poured on a cast-iron table and rolled out into a sheet which, while still glowing, is run into an annealing furnace where it is held at a diminishing temperature for six hours. Upon removal from the latter, the sheet is broken into pieces of different sizes to meet specific purposes. Each piece is carefully inspected for weight and for any discernible optical defects. Keen-eyed girl inspectors do this and make marks on the glass that locate the imperfections and indicate their nature.

The identity of each potful of glass is kept because, even with the utmost care, there are variations in the ultimate composition and optical characteristics of each batch. For that reason the usable pieces of each sheet are segregated and stored for issue as needed. So, too, is the scrap or cullet that can be remelted and utilized as a proportionate part of a fresh batch of the same kind of glass.

In the case of optical glass—using the term in its restricted meaning—the procedure in making up a batch, melting a potful, and stirring it is more exacting in some respects than it is with ophthalmic glass. The pots for the latter can be used repeatedly, but no pot in which optical glass is melted can be used again because the glass is left to cool and to solidify inside of it. The annealing period must be long enough to allow the drop in temperature to proceed slowly, perhaps three to five days, during which the pot is enveloped by a double-walled sheet-iron cylinder and rests on a bed of diatomaceous earth, with which the annular space between the pot and cylinder is also filled.

At the end of the cooling period, the pot is broken to release the glass which, by that time, has developed sheeting planes or incipient fractures that cause it to break into pieces of varying sizes, some large and many of them small. Of all the optical glass, the percentage of usable pieces from a melt seldom exceeds 25 percent. Each potentially satisfactory piece is scrutinized by an expert. In the case of sizable lumps, especially, he notes defects and also the areas from which he can break away large and more or less flat pieces by skillfully directed blows with a sharp-edged hammer. The selected glass must be free of those transparent streaks, called striae, that would make it unfit for lenses or prisms—in short, the glass must be as clear as the most limpid of waters when absolutely still.

Well-nigh all the rough glass is melted or softened after it is placed in molds for casting and subsequent annealing. Much of the latter is done in electrically heated furnaces in which the temperature is automatically controlled within very close limits. For some purposes, pressure is applied to the glass when plastic to give the "blanks" the desired shapes. Compressed air serves to operate the presses utilized for this purpose; in fact, the plant uses compressed air in a diversity of ways in the manufacture of optical glass and is equipped with a number of sizable compressors.

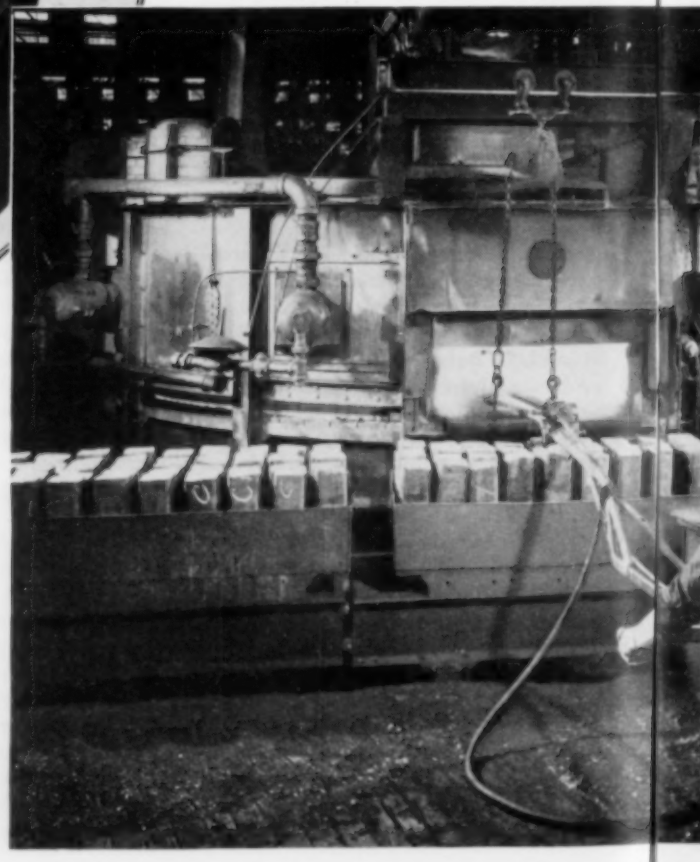
The blanks are placed in reserve for finishing, which comprises grinding to exact curvature to produce the needed optical properties in refracting light and producing images. Finally, the lenses are given their ultimate exquisite polish. Each then undergoes a series of inspections to make sure that it will meet specifications, which demand perfection as far as that is possible of attainment.

The great Bausch & Lomb establishment in Rochester keeps 11,000 workers busy seven days a week, with many departments running the full 24 hours. In addition to the products that immediately serve our fighting men on shore and on ship, there are turned out microscopes, which aid the physician and the surgeon behind the firing lines, and other optical instruments that play their part in producing the metals and materials which contribute to the nation's defense. Without any intention to play on words, the organization is doing its utmost to face the situation and to see it through.

THE picture at the right shows pneumatic lifting bags being used for jacking up a damaged airplane so that a carriage could be placed under it for moving it. The air bags are circled at the right, and the air-cooled gasoline-driven compressor used for inflating them appears in the circle at the left. These bags were developed by the Air Service Technical Command. The plane, the "Big Chief," was a Liberator B-24 bomber that completed 70 missions before coming to grief. It was operated in the South Pacific by a bomb squadron of the famous "Jolly Roger" group (note tail insigne). One day in April, 1944, while it was taking off for a daylight strike at Hollandia, a main-wheel tire blew out just before the craft reached flying speed. This caused the landing gear to break off, and the plane swerved from the runway Luckily, it did not catch fire, and the crew got out with only a shaking up. However, the wreck was a serious hazard to operations on the strip, which could not be closed during this critical preinvasion bombing of Hollandia. The 479th Service Squadron went to work on the salvage job and redoubled its speed when it discovered that the arming wire of one of the 1000-pound bombs had been pulled by the crash. The air bags made it possible to raise the plane much quicker and more safely than the job could have been done with standard hydraulic wing jacks. After the bombs had been removed, "Big Chief" was hauled to the salvage dump. An examination showed it to be damaged beyond economical repair, and it was later stripped of its serviceable parts.

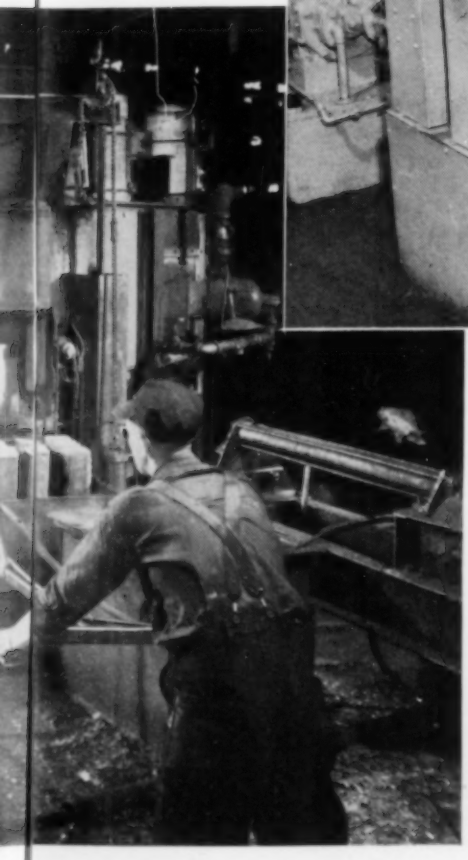
Photo from
L & R Manufacturing Co.

Compressed Air at V



THE machine shown above cleans ball bearings up to 2 inches outside diameter. From 50 to 100 bearings are first put in the basket and precleaned with a solvent in the rotary unit on the left end of the stand. Each bearing is then given an individual pressure cleaning in the unit at the right. The bearing is placed on a spindle and fitted into a stepped, coned head through which the rinsing solution is forced at 6 to 10 pounds pressure. Rotation of the spindle aids in removing dirt and chips from under and between the balls and races. Filtered compressed air at 30 to 40 pounds pressure is then introduced through the coned head to dry the bearing. The tank is sealed during the cleaning period, but a light inside enables the operator to observe the work.

t Work



A STRETCH press in the Glenn L. Martin plant at Baltimore (above) is provided with piston-type pneumatic clamps to hold the work in place. Up to twelve C-type hand clamps were formerly used, and it was time-consuming and fatiguing work for the women operators to manipulate them. They rarely could tighten them equally and could obtain no more than 500 pounds pressure per square inch, so the part being held often slipped. The air-actuated clamps give a uniform pressure of 900 pounds and are operated without effort by means of the lever at the left. Production has increased 15 percent, and the attendants no longer have tired arms and hands. The inset is a close-up of one of the pneumatic clamps in place.

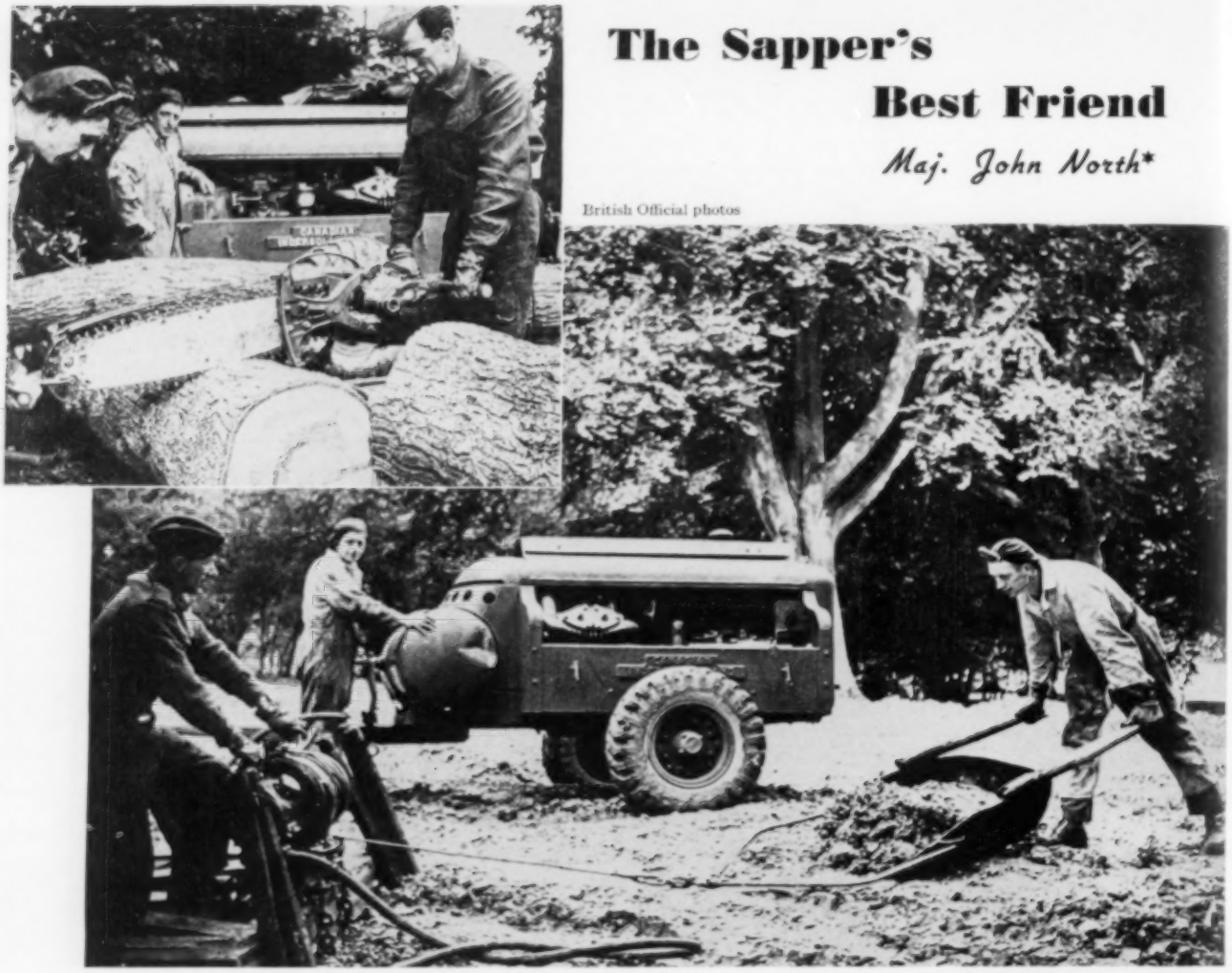
Gulf Oil Corporation photo

IN THE Hagan rotary furnace shown at the left, steel blanks are heated to about 2300°F. and are then forged into shell casings. Along the bottom of each door opening extends a horizontal pipe that carries compressed air under 25 pounds pressure. When a door is opened to put in cold blanks or to remove heated ones, a blast of air blows upward the width of the opening and forms an insulating screen that protects the worker from the heat. The air curtain conveys the hot escaped gases upward through a steel stack. When operating, each screen requires the use of 200 cfm. of air.

The Sapper's Best Friend

*Maj. John North**

British Official photos



USING PNEUMATIC TOOLS

At the top, sappers of the Royal Canadian Engineers are using an air-operated saw to cut up logs for repairing bridges, building tank traps, etc. The other picture shows a Utility air hoist pulling a scraper to fill an excavation. In both cases compressed air was being supplied by a 105-cfm. portable compressor.

THE ubiquitous sapper of Britain's Royal Engineers is very much a front-line soldier. In Western Europe in particular he is in the van of the Allied advance with his own peculiar instruments of war making a vital contribution to the issue of battle. Highest of all in his "armory" he prizes the air-powered tool. In its various types and the extraordinary uses to which it can be put, he ranks it as Weapon No. 1.

Each field company of Britain's Royal Engineers is divided into three platoons, and each platoon is equipped with a compressor truck that carries a number of pneumatic tools. In the normal routine of a sapper's work they are given very little rest. Concrete breakers are particularly useful in the repair of damaged bridges; spades, although employed chiefly for breaking up hard ground during bridge construction, also assist in digging trenches in rocky or frozen ground; augers, designed for boring holes in thick timber, are essential in road and bridge building where local wood is substituted for standard materials; and the air-operated saw can cut logs up to 12x12 inches in a fraction of the time it would take to saw them by hand.

The rock drill is an especially adaptable member of the pneumatic tool family. Newsreel pictures of the war frequently illustrate the need for demolition to clear a path through obstacles left by an enemy in retreat. For example, partly wrecked structures that endanger the advancing army have to be razed, and in work of that kind the rock drill plays a prime part in boring the necessary blast holes in masonry. It is this tool, too, that drills the hole that takes the small mine charge or *camouflet*. If a road or a runway has to be mined for operational reasons, the same procedure applies.

Conversely, the rock drill and its close relative the concrete breaker are essential equipment in repairing demolitions. For instance, if a bridge has been "blown," the abutments will usually be found intact even though one or more of the spans may have dropped. However, those buttressing or supporting parts of the structure will have to be "tidied up" before they can receive the "transome," as the horizontal sections are called. In these circumstances, explosives are generally barred to prevent further shattering of the abutments. The more effective method is to chip away the damaged masonry with a concrete breaker.

Should there be no alternative to the use of explosives, then rock drills are pressed into service and the sapper resorts to what is called a "shaped charge." This works on the sticky-bomb principle; and, as the name implies, confines the effect of the detonation to a limited area. Drills of this type are equally necessary in conducting improvised quarrying operations in forward zones of action. These are the occasions when really big blasting charges are employed, and the air-driven drill is likely to be the spearhead of the attack.

*A British staff officer

Pneumatic tools make their most dramatic appearance, perhaps, in an element which, at first sight, would appear to be singularly outside their province. We all know how vital it was for the Allied armies in Europe to have high-capacity ports ready for use at the earliest possible moment in order to maintain supplies. It was for this reason that Britain's War Office organized and lavishly equipped Port Construction and Repair Companies. Before the enemy evacuates a port he will, if he has time, obstruct its entrance with ships, "blow" the harbor moles and jetties, or block them by sinking floating derricks, lighters, schooners, or other craft, large and small. If he has no vessels available for that purpose, he can obstruct the quays equally well by dumping into the water all manner of vehicles, tractors, cranes, aircraft, and even bombs and shells. In any event, the repair party will be faced with a mass of tangled wreckage of one sort or another, and this will entail what Britain's sappers call "breaking work." There, too, the air-operated drill will be one of the first tools on the scene.

MOBILE AIR SUPPLY

A trailer-mounted portable compressor attached to an army truck ready for towing. The latter carries various air-driven tools and also men to operate them.

In this war—as indeed in any war—one hears a great deal of talk on the subject of manpower. War is a form of work, and one naturally thinks of work in terms of manpower. In turn, one thinks of manpower in terms of man-hours. If manpower were the only consideration, it would be easy on this basis to forecast the outcome of any war. Other factors being equal, the nation with the greater manpower would emerge victorious. However, we live in a machine age, and it is a fair argument that in war production what ultimately counts is not man-hours but machine-hours. A tool that increases the output of machine-hours is helping to win the war, and that, on the word of every sapper of Britain's Royal Engineers, goes for the pneumatic tool.

CANADIAN TROOPS DRILLING BLAST HOLE IN ROAD BLOCK IN HOLLAND

Honduran Road

Monument to Inter-American Amity

*Graham S. Quate**

DEDICATING NEW ROAD

Brig. Gen. George A. Dunham, executive vice-president of the Institute of Inter-American Affairs and an authority on tropical diseases, is seen above speaking at the dedication ceremonies of the new 40-mile highway. The picture below shows the monument, on a site overlooking Lake Yojoa, which bears the words, "Dedicated to the causes of friendship and peace."

OVERLOOKING beautiful Lake Yojoa in Honduras from a point near Agua Azul is a monolith of concrete marking the completion of a 40-mile modern highway that skirts the lake. The new road is an important part of the Inter-Oceanic Highway of Honduras and represents a step forward in solving one of the country's basic economic problems—the need for better internal communication. The road also is a monument to inter-American friendship, as expressed by a plaque on the monolith that bears the following inscription: "Inter-Oceanic Highway, Pito Solo-Potrerillos. Constructed by the Republic of Honduras in coöperation with the United States, 1943-1944. Dedicated to the causes of friendship and peace."

Behind these words is the story of a wartime economic crisis that confronted Honduras in the summer and autumn of 1942 at the height of the submarine campaign against Allied shipping in the Caribbean and the Gulf of Mexico. The resultant shortage of bottoms drastically curtailed banana shipments, which for many years had accounted for from 75 to 80 percent of the total Honduran exports. They were consigned mainly to the United States. When banana boats were diverted to war service, or were destroyed by enemy torpedoes, nearly half of the 30,000 men in the principal fruit-growing sections lost their jobs or faced unemployment. Many went into the interior and turned to subsistence farming, other thousands remained idle in north-coast towns.

It was to meet just such crises that the principles of coöperation among American republics were laid down at the Rio de Janeiro conference of foreign ministers in January of 1942 and at the preceding inter-American meetings. When the severity of the situation became apparent, efforts to alleviate it were at once launched. On behalf of the United States, the Office of the Coordinator of Inter-American Affairs conducted a survey in September, 1942, which indicated that some 8000 workers were still jobless. Discontent had become manifest. The Honduran Government alone was unable to cope with the unemployment problem because its revenue had been reduced through loss of import and export duties. Discussions with Honduran officials quickly led to the decision to undertake the construction of a road from Potrerillos to Pito Solo. To start it, the Institute of Inter-Ameri-

*Office of Coordinator of Inter-American Affairs

can Affairs, an agency of the Coordinator's office, made an initial allotment of $315,000. By the end of 1942 nearly 2000 men had been given work on the project and the crisis was well on the way toward solution.

The plan to improve overland communication from the north coast to Tegucigalpa, the inland capital and chief commercial city of Honduras, was made with full knowledge of the vital part highways play in developing national economy. Probably nowhere else in the Americas is the need for internal transportation more obvious than in Honduras. In an area of nearly 60,000 square miles and with a population of about 1,200,000, the country in 1942 had less than 800 miles of roads of which less than 600 miles were passable by automobiles. Tegucigalpa, founded in the sixteenth century, is approximately 200 miles from the Atlantic Coast and 100 miles from the Pacific. Freight and travelers to and from the city go toilsomely over hills and mountains by mule, bus, and truck, save when carried by airplane. Transportation is therefore a considerable item in the cost of imported foods and manufactured goods.

About half the imports flow in through the north-coast ports and are hauled 60 miles by rail to Potrerillos, moving thence by bus and truck, or by mule, to the capital. Before the construction of the Potrerillos-Pito Solo highway, traffic crossed Lake Yojoa by ferry. As a scenic ride, the ferry stage of the overland trip is unbeatable; but as an economic proposition, it is not so attractive. Besides the payment of toll, there is the loss of time in transferring from road to ferry and the slow lake travel.

Within its financial capacity, Honduras has been working for some years to improve its roads. Construction is proceeding on its sections of the Inter-American Highway, which eventually will afford overland communication between the United States and the Panama Canal. Until the coming of air transport and motor routes, the economics of Honduras and of other Central- and Latin-American countries depended mainly upon shipping from coastal ports or trade by rivers. But the Inter-American Highway alone will not suffice to alter the situation. In Honduras, that traffic artery runs along the Pacific Coast side. Interocean connections with it are needed, and that is where the Potrerillos-Pito Solo road fits in. It closes one of the chief gaps in the interoceanic route which will tie in with the Inter-American Highway to provide overland communication for buses, trucks and automobiles.

It takes but little stretch of the imagination to picture the economic possibilities of Honduras when interconnected by an adequate system of roadways. Although broken by mountains and hills, the republic is well timbered and abounds in minerals. With high transportation costs, it has been pro-

HONDURAN SCENES

The rambling structures in the bottom picture are in a part of Pito Solo, which is on the shore of Lake Yojoa and is the western terminus of the new highway. The other view shows one of the trains of the National Railroad with which the new road joins at Potrerillos.

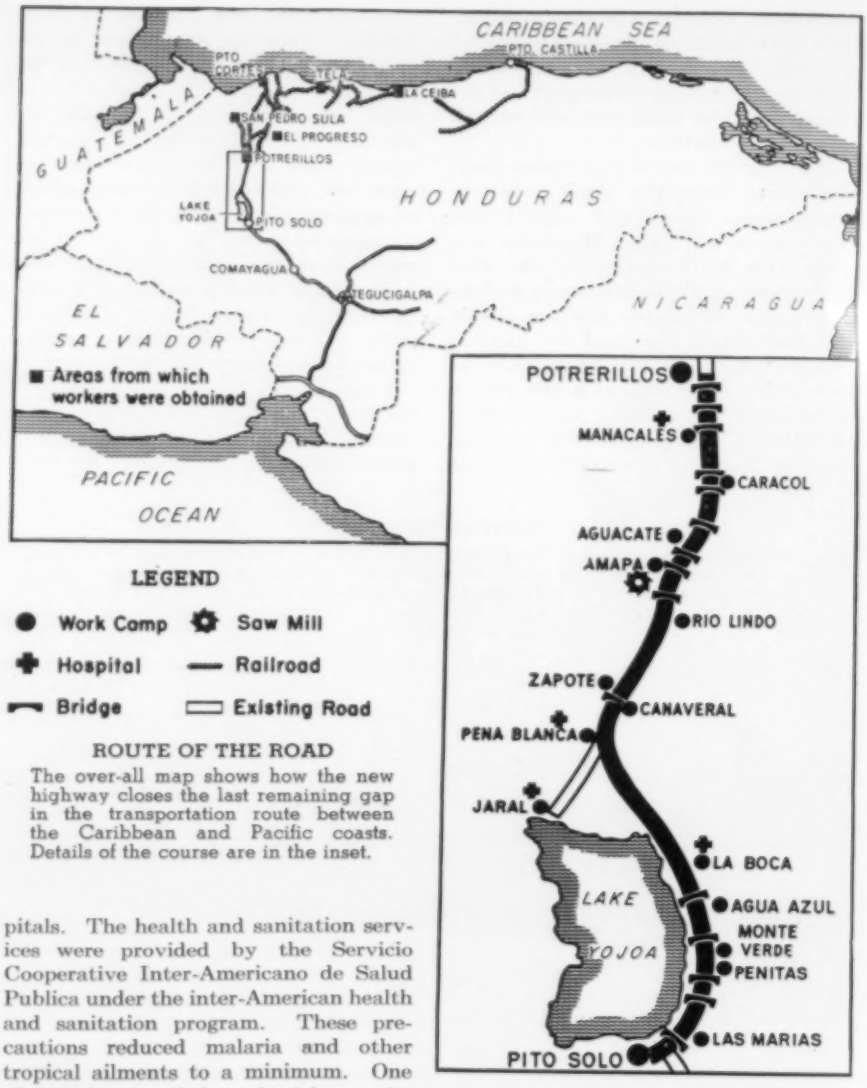
fitable to exploit only gold and silver in any considerable commercial quantities. Silver mines near Tegucigalpa are among the most productive in the hemisphere. The name of the capital city is derived from the Indian words "silver hills." Fertile valleys give promise of more food for home consumption—greater agricultural development, which is already being realized through the recent opening of an agricultural research center and school near Tegucigalpa and the inauguration of a wartime food-growing program by the Honduran Government in cooperation with the Institute of Inter-American Affairs.

Thus the 1942 shipping shortage, with its disastrous effects, made plain what type of project would best serve Honduran needs—would provide both emergency employment and something of enduring value. It was generally agreed that a road built from railhead at Potrerillos around Lake Yojoa would be the most advantageous undertaking from both standpoints, and would at the same time improve overland communication with the capital. So, with U-boats hammering at Caribbean supply lines, and with banana exports almost suspended, work on the highway began in the autumn of 1942 under the direction of a veteran engineer from the U. S. Public Roads Administration, Andrew K. Haxstun.

Plans for the project were worked out with the following multiple benefits in mind: first, to give emergency employment for displaced banana workers and thereby prevent business collapse in the area; second, to provide a transportation link essential to the country's long-range economic development; third, to serve as a training ground for Honduran engineers and handlers of machinery; and, fourth, to demonstrate the technique of modern roadbuilding and the value of good highways.

Low-cost construction was a necessary factor, and the project was laid out accordingly. To reduce expenditures, locally available materials were used wherever possible. In the absence of gravel, crushed stone proved satisfactory. The Honduran Government supplied most of the equipment. However, with machinery and fuel hard to obtain, hand labor substituted for machines to a considerable extent. Such mechanical items as power shovels were scarce. One diesel bulldozer was finally hauled in from Olancho, 250 miles distant. Engineers had to go as far as Nicaragua to find a gasoline-driven, electric welding machine.

Despite wartime obstacles, operations went ahead through 1943 and into 1944. The problem of keeping the workers well and vigorous was taken care of by sanitary inspectors who supervised the work camps, by malaria control, and by the establishment of three small hospitals. The health and sanitation services were provided by the Servicio Cooperative Inter-Americano de Salud Publica under the inter-American health and sanitation program. These precautions reduced malaria and other tropical ailments to a minimum. One of the few who died on the job was the United States engineer Haxstun, who succumbed in the summer of 1943.



LEGEND

Work Camp — Saw Mill
Hospital — Railroad
Bridge — Existing Road

ROUTE OF THE ROAD

The over-all map shows how the new highway closes the last remaining gap in the transportation route between the Caribbean and Pacific coasts. Details of the course are in the inset.

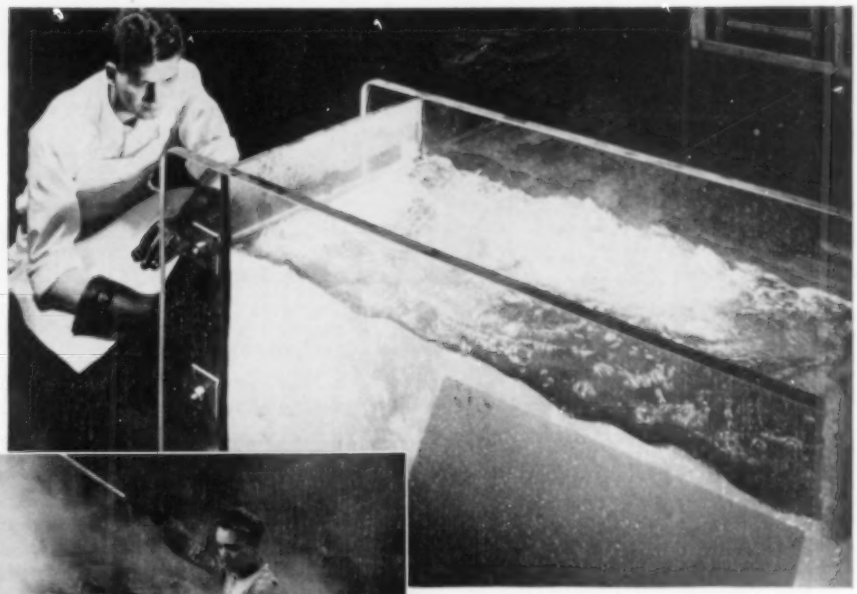
In the meantime, as had been hoped from the outset, the economic crisis in Honduras had passed. Shipping began to improve in the latter half of 1943. When the highway was completed, bananas again were moving out of the country in substantial quantities and hundreds of workers shifted back to old jobs. At the same time, new employment opportunities arose with the increase in production of fibers, rubber, and other strategic materials for United Nations war industries. Furthermore, the training given Hondurans in skilled and semi-skilled road work aided them in finding other employment upon the conclusion of the project.

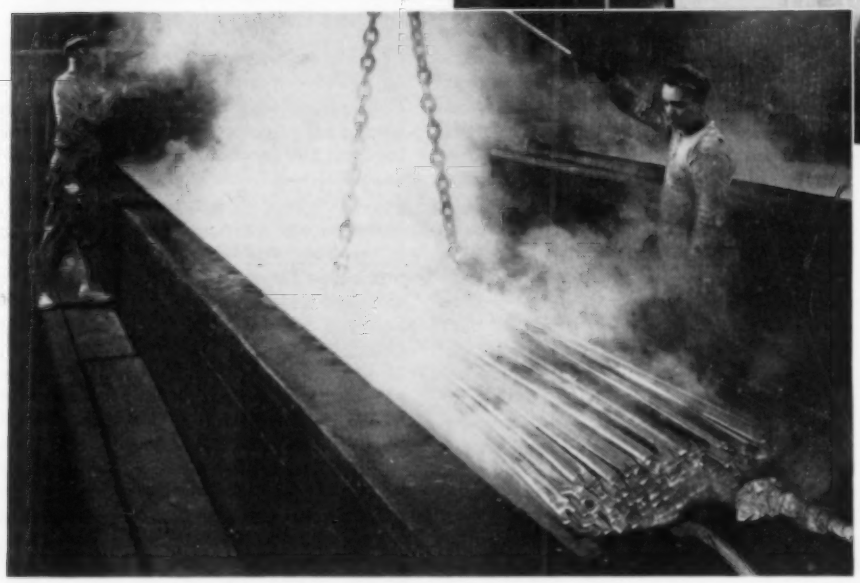
As the highway progressed, its economic effects upon the surrounding country became apparent. More than half of the money paid out, $700,000 in all, went for wages, and immediately entered local trade streams. The longer-range significance of the road in terms of national development also became evident. A mahogany logging operation was started at the south end of the lake. The main benefits, however, will probably not be realized until after the war. Overland transport in Honduras, as in most places in Latin America, is now hampered by shortages in fuel and motor parts—by the difficulty of obtaining additional motor equipment.

The Potrerillos-Pito Solo highway is of macadam construction on a rock base. It is built to endure. Its maintenance has been taken over by the Honduran Government under agreement with the Institute of Inter-American Affairs. The material value of the road as a factor in the republic's economy and in the solution of a wartime emergency is readily demonstrable. Its importance as a bond in inter-American friendship was stressed by Honduran and United States officials at the dedication ceremonies on September 1, 1944, when the Inter-Oceanic Highway was turned over to the Honduran Government, and is the theme of the monument erected in commemoration of the project at Agua Azul.

HIGHLY CHEMICAL RESISTANT

The all-glass tank at the right is undergoing a boiling test and is built for use with hot chromic acid. Containers of this type are made of either clear or opaque Herculite, transparency being of advantage in many applications. The other picture shows a glass-lined vat, 28 feet long, in which steel bars are pickled in a 15 percent sulphuric-acid bath at 185°F. The plate glass that enters into the construction of these tanks is highly resistant to breakage. This is proved by the fact that a piece 12x12 inches square and ¾ inch thick, supported only on the edges, will not crack under the impact of a 5-inch duckpin ball dropped from a height of 26 feet.





Tanks of Glass for Heavy Industry

MOST of us consider glass a brittle material and would be surprised to learn that it is substituting for metal in the manufacture of pickling, plating, and other similar tanks for heavy industry. This has been made possible, it is announced, by the Herculite or heat-treating process, perfected by the Pittsburgh Plate Glass Company, that increases the strength of a given thickness of glass from four to five times and enables it to withstand continuous working temperatures of 500-600°F.

Two types of glass tanks are now available: one made entirely of either opaque or transparent Herculite ⅝ to 1¼ inches thick, depending upon service requirements, and the other consisting of a metal or wood shell lined with ½-inch glass. In the case of the latter, the lining is held away from the casing by spacers that also serve to put pressure on the joints, which are filled with glass-cloth gaskets. In the space between the shells is a continuous acid-resistant membrane which is applied by a special process. The dimensions of the lined tanks are usually 9x6x5 feet, being limited by the size of glass plate that can be made.

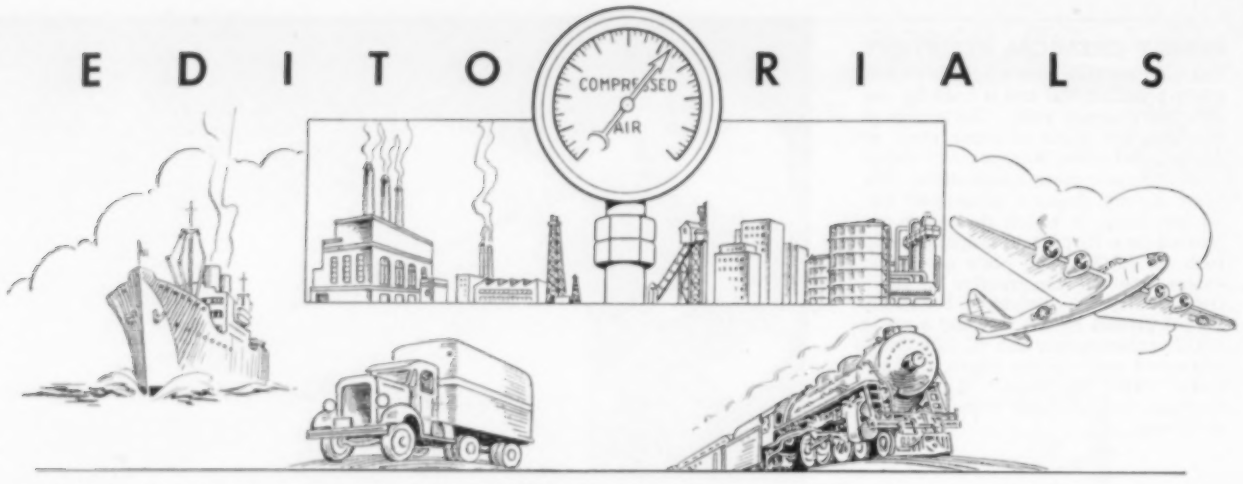
The all-glass type has a maximum length, inside, of 8 feet, a width of 5 feet 10 inches, and is 5 feet deep. There is an inner lining of Herculite white Carrara on the bottom, and the side walls are grooved at the joints to take gaskets of impregnated glass cloth, the impregnating material varying with the solution to be put in the tank. This gives it an advantage over the lined vat because it permits the use of hot chromic and hot nitric acids. Noncorrosive Monel-metal or stainless-steel tie rods hold the plates together.

The idea of making glass tanks for industrial applications where mineral, organic, and pickling acids represented a problem received an impetus shortly after the attack on Pearl Harbor when a large concern was unable to get replacements for a battery of conventional tanks that had become corroded. The first one was manufactured more than a year and a half ago. It was an all-glass unit; and since then this as well as the lined type have been put in production by the Pittsburgh Plate Glass Company and are being used in many plants, pharmaceutical houses, and steel mills. With the exception of solutions containing hydrofluoric acid or heavy concentrations of caustic, they are said to be impervious to acids that destroy every other kind of material of which tanks of this kind are commonly constructed.

Tubing that Descales Itself

TUBING that is said to descale itself has been announced by Heat Transfer Products, Inc. This unique piping is oval in form and has a strip of metal bonded to it from end to end. The parts are made of materials having different rates of thermal expansion so that as the tube proper expands under heat the strip tends to retard expansion on its side, thus causing the assembly to flex and to crack off any accumulated scale. The metals vary with the application. In the case of distilling equipment used on shipboard to convert salt into fresh water, the tubing is of Admiralty brass and the strip of Monel metal with an expansion coefficient 32 percent lower than that of the brass.

EDITORIALS



RAILWAY RROGRESS

JUST eighty-five years ago this month, the Pony Express service was inaugurated to provide "fast" communication between the eastern states and far-off California. Relays of riders, changing mounts every 10 or 15 miles, regularly rode from St. Joseph, Mo., to Sacramento, Calif., in ten days, and a record of seven days and seventeen hours was set in delivering Lincoln's first inaugural address. There was then no telegraph or railroad service, and the overland stage required 24 days to make the journey. Nine years after the Pony Express was started, it was possible for the first time to ride by train across the United States. Since then our rail system has grown to where it now ranks first in the world, with more than 20 miles for each 10,000 inhabitants.

The railroads were responsible for the development of agricultural and industrial America, and they prospered for many decades. With the coming of the automobile and, later, the airplane, their revenues declined during an era when costs were mounting, and the depression of the thirties put many lines in or close to bankruptcy. Fortunately, the war has replenished their coffers and put them on a firm financial foundation for the competitive period that lies ahead. By and large, the railroads are, concededly, doing a fine job in moving unprecedented freight and passenger traffic, despite shortages in manpower and equipment. It is also interesting to note that, even during the trying times they have been experiencing, they have spent time and money on a program of improving equipment, track, and service.

This work has been carried on as a coöperative endeavor under the auspices of the Association of American Railroads in conjunction with manufacturers and suppliers of railway equipment. Collectively, they have expended many millions of dollars. Back in the 1920's, the railroads alone paid out $2,350,000 for research on air brakes and another million to develop a standard car coupler, both of which measurably increased safety. More recently they have been investigating freight-car trucks to insure smoother riding, snubbers to reduce vertical vibration, improved draft gear, and lighter cars. War conditions have slowed up these efforts, but various committees are planning a postwar freight car that will, among other things, be lighter.

Everyone is so familiar with streamliners and air-conditioned trains that they need be only mentioned. Concurrent with the adoption of diesel-electric locomotives, great betterments have been made in steam locomotives for high-speed service. Boiler capacity has been increased, reciprocating parts lightened to reduce inertia, and counterbalancing improved. The art of signaling has steadily advanced, and one operator now keeps in touch with all train movements in his territory by merely watching lights on a track-diagram board. Experiments are continuing with radio in train and terminal operations.

Research on track and structures is also going ahead. It has been found that controlled cooling of rails after they are rolled virtually eliminates transverse fissures in service. Other work concerns a better design for rails that will afford increased resistance to wear. Chromium-bearing rails are being tested under operating conditions. Numerous stretches of all-welded rail have been laid and are undergoing study. As the rail joint accounts for a large part of track maintenance costs, it is being given close attention. Track bolts, although small individually, bulk large because there are 250 million of them in American railroads, and efforts are being made to reduce the stresses to which they are subjected. Better ballasting is the objective of other investigations.

In carrying on these diversified endeavors, laboratories have been established at various leading engineering colleges to work on particular problems. All in all, our railroads are bent on continuing to improve and economize their services and on maintaining the indispensable place in the transportation field that they now hold.

SPRING IS HERE

THIS is the season when the Victory Gardener comes into his own again. Following a long hiatus, he is once more taking his implements in hand and turning over the good earth. Seed catalogues are preferred reading, and conversations are tinctured with horticultural terms.

Americans have surprised even themselves in so wholeheartedly going in for miniature farming. Reputedly a nation softened too much to take to the spade and the hoe, it has made the Victory Garden more than a phrase. Dr. Charles H. Connors of the College of Agriculture at Rutgers University says that more than 40 percent of the vegetables used in the country last year were raised on small plots. The need of continuing the effort in 1945 is even more acute, for farmers are losing their sons and hired men to the armed forces and cannot get replacements for worn-out machinery.

Most Victory Gardeners get more than food from their efforts. Along with vegetables, they reap self-satisfaction. There is no prouder person than the man that raises the biggest tomatoes or the sweetest corn in his block. The exercise of digging and planting is a welcome and health-giving tonic after a season of snow, cold, and muscular inactivity. Pleasure drivers have been transformed into pleasure farmers by the thousands, and legions of men are finding out that they can grow better-tasting produce than they can buy in stores.

Those who live in apartments or whose home premises are not sufficient for a garden have learned that it is an easy matter to get a factory plot, a vacant lot, or to share in a community enterprise. Civic programs are invariably run by men beyond military age who are glad to give their time to such a cause, and they don't squander a cent. In our own community of Phillipsburg, a 50x100-foot plot is rent free, but $2 is collected to pay for plowing. In 1943 there was a 50 percent refund and in 1944 it was 40 percent. A small price, indeed, for a season's recreation and hundreds of pounds of fresh, tasty vegetables.

Two Letters from England

CAMBORNE

Sir: I was very much interested in the article, *Tunneling at Gibraltar* in your October issue, but having many friends in the Royal Engineering Companies who were engaged on this work back in August, 1940—and who were in fact responsible for certainly two-thirds of all the excavations carried out—I am surprised at the prominence you have given to the work of the Canadian Royal Engineers. In fact, any one reading the article would assume that they had done the major portion.

Also to say that the Canadian R. E. had to teach the Royal Engineers the use of wet mounted drifters is absurd as, although possibly a large porportion of the rank and file were drawn from the colleries in this country, the majority of the officers were metalliferous miners and had worked such machines in all parts of the world, including Canada.

As the rock at Gibraltar is limestone, except for specialized work the small hand-held machine, drilling dry, was proved to be the most effective; in fact, all the records for advancement or excavation are held by the Royal Engineers, using hand drills.

To say that the diamond drill was new to personnel of the Royal Engineers was also not true in fact, as many of them had handled these machines in all parts of the world, including Cornwall, since shortly after the last war.

NAME WITHELD BY REQUEST

EDITOR'S NOTE: *Some two years or more ago we sought information from England regarding drilling at Gibraltar, but were informed that nothing could be released until after the war. Subsequently, we were able to get from Canada the material we published. In the opening paragraph we stated that our account "concerns principally the part played by Canadians." The statements we made were in accord with those written for several Canadian publications by men who were at Gibraltar. We are sorry we could not tell more about the work done by the British Royal Engineers.*

LONDON

Sir: In one of the illustration captions of the article, *75 Years of Air Brakes* in your December issue you state, "The air brake was eventually accepted by virtually all countries except England." On examination of the records, you will find, I think, that Great Britain has the lowest crash rate of all the major world railway networks.

The burden that the British railways have carried these past 5½ years, especially around D-Day, has been terrific. Passengers on long-distance trains (long, that is, for this little isle—400 miles), civilians, troops on leave, etc., not only have to stand perhaps all night but are sometimes to be found literally *packed in layers* in the corridors. And tank- and gun-trains and the rest are sandwiched in between these trains, giving an enormous load on the lines. Yet the bad wartime crashes can be counted on one hand.

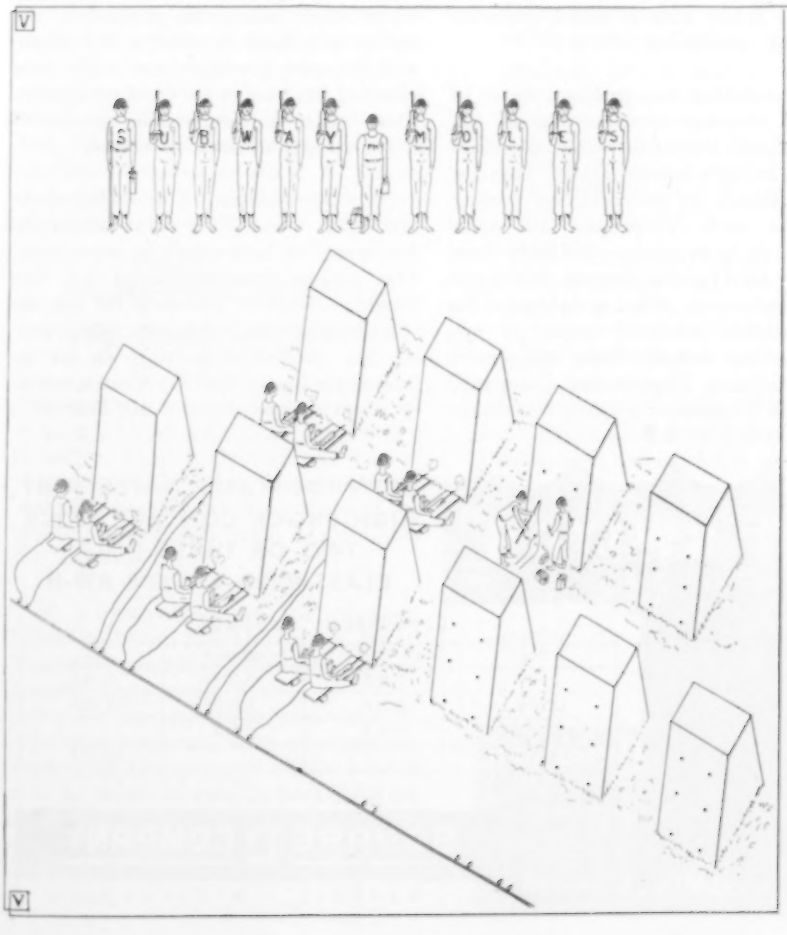
THEODORE A. RAYMOND
(*No connection with railways or brakes—just a reader.*)

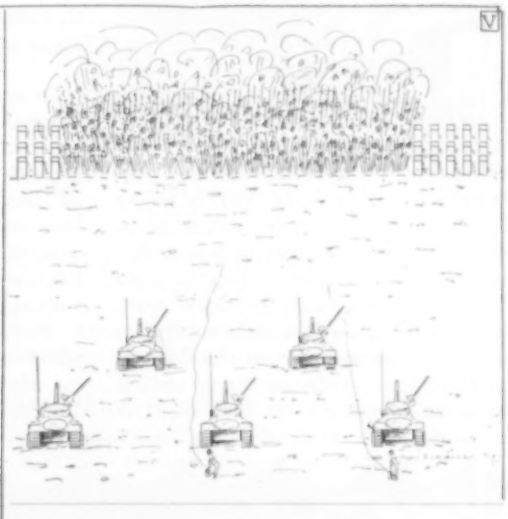
Electric Soldering Machine Expedites Work

TO EXPEDITE the manufacture and repair of welding cables, two employees of the Philadelphia Navy Yard have made a heavy-duty soldering machine that is said to do a finished job in about 1½ minutes. The unit simplifies the operation of applying or removing the lugs that are attached to electric cables.

Soldering is effected by locking each lug in a jig and, at the same time, to one side of an electric contact. Then the cable is threaded through the holding loop and inserted in the lug; a second contact is made at the other side of the lug; and the primary control switch is thrown on, causing both the lug and the wire to be heated uniformly and the solder to melt instantly. With the job completed, electric contact is broken and a jet of compressed air is automatically blown over the contacts and the work, thus cooling them and carrying the hot gases away from the operators. Removal of the lugs is accomplished by a quick-release handle.

The apparatus offers many advantages, it is reported, over the methods previously employed at the Navy Yard for the purpose. It eliminates the use of gasoline as well as preheating; prevents the formation of gas fumes and spilling of molten solder; and has effected a saving of three minutes per cable, or $125 a month in the manufacture and repair of 2000 cables.





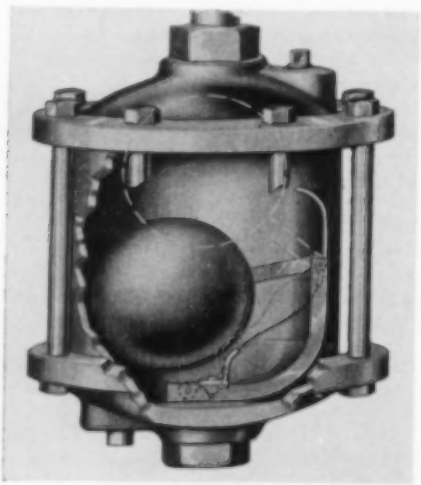
THE MOLES AT WAR

Each February The Moles, a New York organization of tunnel and heavy-construction men, holds its annual dinner. Early this year, one of their number, George Perrine of Burr Brown Associates, Inc., fell to daydreaming of what The Moles could do if they were turned loose on the Siegfried Line with rock drills and dynamite. He decided to put his vision on paper for the edification of his associates at the dinner, and here is the result. The right-hand panel visualizes the shot following the drilling and loading pictured at the left. Mr. Perrine omitted some of the tank and infantry divisions to save paper for war purposes.

Industrial Notes

It's standard practice at the ready-mixed concrete plant of the Fort Worth (Tex.,) Sand & Gravel Company to remove hardened concrete from the transit mixer drums by a pneumatic chipping hammer supplied with air by a portable compressor. It's been found to be the easiest and quickest way to do the work.

The no-prime Zip Action Trap recently developed by Jas. A. Murphy & Company is a useful accessory to compressed-air pipe lines using pressures up to 125 pounds per square inch. According to the manufacturer, an oversize throat guarantees quick expulsion of the condensate, and there is no leakage of air even under the severest service. Opening

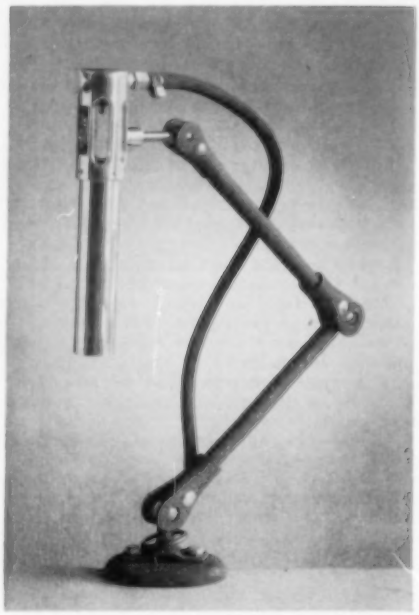


and closing of the valve is so fast that ordinary dirt, pipe scale, rust, or heavy oil cannot prevent it from seating properly. The cycle of operations is as follows: As the condensate enters the body of the trap, a ball float gradually rises, causing a stainless-steel strip spring attached to a short lever on the float to straighten and to store up energy until it passes dead center. At that point it snaps the valve wide open. As the water level drops, the cycle is reversed and the valve is closed with the same positive action. For cleaning, it is necessary only to remove the base plate; and any throat obstruction by an overlarge piece of scale, etc., can be cleared away by taking out the bottom pipe plug. The new unit has a diameter of 8½ inches and is 10½ inches high.

Wheelbarrow pushers note. Dow Chemical Company is going to manufacture a barrow that will weigh 30 pounds—55 pounds less than the type commonly used. This saving is effected by making the body of magnesium—Dowmetal—instead of steel and the frames of tubular metal. To further ease your burden it will run on antifriction bearings and a pneumatic tire.

Spray Mix is the name of a new refractory that has been put on the market by Mexico Refractories Company for relining spalled and eroded furnace walls and arches. The material is supplied dry in granules for mixing with water, or in mastic form, and is applied by air spray or hand plastering in successive coats of ½ to 1 inch until the lining is of the desired thickness. The refractory is said to have a fusion point equal to that of first-class firebrick and to bond firmly with it under ordinary operating conditions.

In metallizing, one frequent cause of cracked coatings is expansion of the base material through overheating while the new metal is being applied. This can be prevented, we are told, by cooling the area with compressed air while spraying is in progress. Ordinary hose has been used for this purpose, but is not very satisfactory. What is claimed to be a thoroughly practical means of application has recently been announced by Metallizing Engineering Company, Inc., and consists of a heavy-aluminum

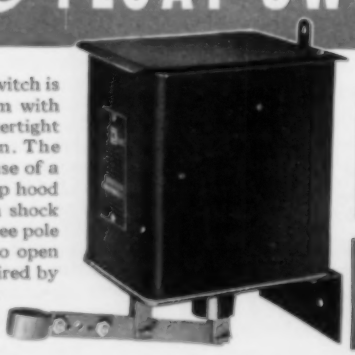


ejector tube so mounted that it can be clamped or bolted to a lathe carriage, bench, boring mill, or spray booth and instantly adjusted to any operating position. The device is known as the Metco Siphon Air Blast and delivers 60 cubic feet of air per minute with an air requirement of only 4.5 cfm. Except where work has to be preheated, the siphon is turned on after a few passes with the spray gun have been made, thus allowing the base metal to expand somewhat before an appreciable amount of the coating has been deposited.

By a new method of soldering silver and other low-melting-point alloys the flux is applied to the work in vapor form. The process was developed by The Gasflux Company and calls for the use of a container for a specially compounded flux carried in solution in an inflammable liquid that evaporates quickly when exposed to the air, and of a

Marine FLOAT SWITCH

DRIPPROOF AND WATERTIGHT
HIGH SHOCK CONTACT BLOCK
TWO OR THREE POLE
CLASS 9036 • TYPE AW-H



● The class 9036 type AW-H float switch is built for Marine Service to conform with requirements for a dripproof and watertight device of shockproof construction. The switch differs from standard in the use of a special sheet steel enclosure and drip hood with gasket seal and a special high shock bakelite contact block of two or three pole form. The switch can be arranged to open or close on rise in liquid level as required by application. Mounting is three point by means of bracket flange and foot, as illustrated. **Write for Bulletin 563.**

ELECTRICAL RATINGS

Voltage	Single Phase A. C.	Polyphase A. C.	D.C.
110V.	2 H.P.	3 H.P.	1 H.P.
220V.	3 H.P.	5 H.P.	1 H.P.
440-550	5 H.P.	5 H.P.	.....
32V.	.....	.....	½ H.P.

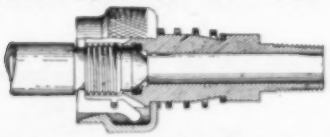
REGULATOR DIVISION
SQUARE D COMPANY
DETROIT • MICHIGAN

regulating device interposed in the fuel-gas line. On its way to the torch the flux is picked up by the gas in its passage through the tank and is vaporized by the flame, while the regulator permits varying the supply with the job. The advantages claimed for the Gasflux method are that it obviates unbonded joints by the use of too little flux and that it virtually eliminates the usual finishing operation of residual-flux removal.

The accepted method of insulating coils, armatures, transformers, and other electrical components is by first pulling a vacuum on them and then applying compressed air to the solution in which they are immersed. Parts so treated are thoroughly impregnated and therefore have advantages over those that are just dipped in the solution. Ordinarily the work is done at the point of manufacture, but it is now possible to have it done in plants that are especially equipped for the purpose.

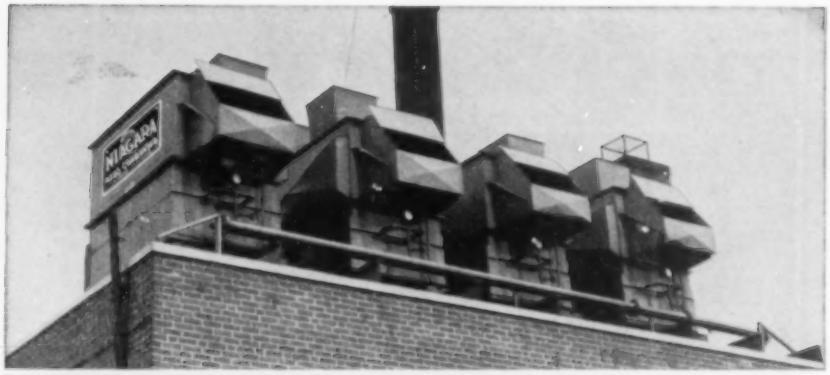
Chrysotile asbestos of good spinning quality has heretofore been found in the United States only in limited quantities. Now, ironically, the Vermont Asbestos Mines have opened up a large deposit of this mineral near Eden that has fibers of unusual length. The fact of the matter is, reports the U. S. Bureau of Mines, that asbestos with fibers more than 2 inches long is rare and that the present-day machines by which the material is handled are not suitable for opening and carding fibers from 6 to 12 inches long.

Volume production has been begun by the E. B. Wiggins Oil Tool Company, Inc., on a direct-connect coupling that has been designed especially for testing operations. It fits over the end of any standard Type AND 10056 nipple and



ranges in size from ¼ to ¾ inch. Connection with an air or fluid line takes a second or so, it is claimed, the dogs of the coupling gripping securely in the undercut just behind the threads of the nipple. The unit is made of aluminum for durability.

It is announced by the Missouri School of Mines and Metallurgy, Rolla, Mo., that graduate fellowships of the Mining Experiment Station are open there for the academic year 1945-46. Advanced academic work and research leading to Master's and Ph.D. degrees may be taken in mining (including the mining and petroleum options), ceramics, metallurgy, or geology. Applicants should address inquiries to Dean Curtis L. Wilson.



NIAGARA
Evaporative COOLING
Does It Better

Cooling Fluids with Closer Control of Temperature

Niagara Aero Heat Exchanger cools liquids or gases to within 10° of atmospheric wet bulb temperature and holds them to a tolerance of 2°F. with the NIAGARA "Balanced Wet Bulb" control.

"BALANCED WET BULB"
TEMPERATURE CONTROL

U. S. Patent Re-issue No. 22,533
U. S. Patents 2,166,397; 2,296,946;
Re-issue No. 22,553
Other Patents Pending.

Holding Temperatures of Quenching Baths

Hundreds of heat treaters now use Niagara Aero Heat Exchanger to cool and control quenching baths, improving quality, increasing production, avoiding troubles, and saving cooling water expense.

Compressed Air After-Cooling

Niagara Aero After Cooler cools compressed air colder to eliminate one-half the moisture permitted by conventional methods and controls jacket water temperature. Saves cooling water cost.

Condensing Refrigerant Gases

Niagara Duo Pass Aero Condenser saves power, increases compressor capacity, saves condensing water cost, increases plant production. Duo Pass prevents scale formation; assures full capacity always.

OTHER USES OF NIAGARA AERO HEAT EXCHANGERS include chemical and industrial process liquid cooling, engine jacket water cooling, hydraulic fluid cooling, transformer oil cooling, lubricating and cutting oil cooling, water jacketted bearing and furnace cooling, vapor and steam condensing.

Consult your Niagara Engineer for information on any application of air engineering equipment, including air conditioning for industrial processes, NIAGARA "No-Frost" refrigerating systems for storage or process, heating, cooling, drying or humidification.

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Over 30 Years of Service in Industrial Air Engineering

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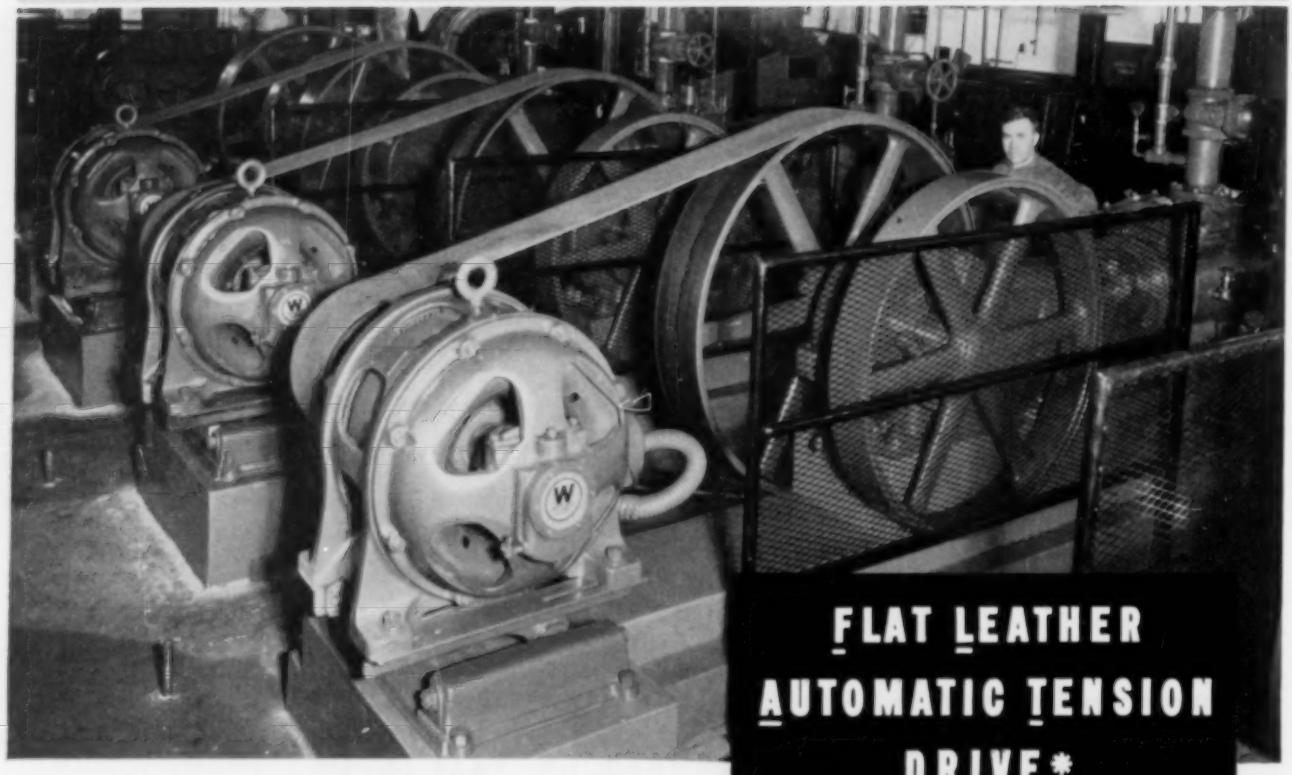
Field Engineering Offices in Principal Cities

INDUSTRIAL COOLING HEATING • DRYING
NIAGARA
HUMIDIFYING • AIR ENGINEERING EQUIPMENT

THIS DRIVE CALLS FOR *Research*



The Flat Leather Automatic Tension (pivoted base) drive is your logical choice for driving compressors. The pivoted base maintains proper belt tension. When the load is light, belt tension is relaxed; when the load is heavy, the belt tension is **automatically** adjusted.

This drive, using Graton & Knight "Research" belting, meets the requirements of compressor drives because it adjusts itself to high inertia starting loads, cut-in and cut-out operating conditions and pulsating loads.

***Drive illustrated: Compressors, three 14 x 10; motors, 75 hp; motor pulley, 19"; compressor belt wheel 58" with 10½" face; base, Rockwood; belt 10" Research Double, G & K #5.**

For all F.L.A.T. drives use Graton & Knight "Research". It has the ideal qualities for service with pivoted bases:

- **Highest coefficient of friction**
- **Flexibility so that it hugs the small pulley with minimum slip, thus reducing tension needed**
- **Natural elasticity to absorb sudden or peak loads**
- **Least stretch, guaranteeing long, uninterrupted performance**

A "Research" belt on the F.L.A.T. drive will outlast a rubber V-belt by 2 to 1. Full details are given in Leather Belting Manual. Write Graton & Knight Company, 365 Franklin St., Worcester, Mass.

GRATON AND KNIGHT

Research Leather Belting

The most complete line . . . manufactured under one control from green hide to finished product. Graton & Knight distributors are listed under "Graton & Knight" in "Belting" section of Classified Telephone Directory and THOMAS' REGISTER.

From jitterbug ride to velvet glide — by rubber

A typical example of B. F. Goodrich development in rubber

THE postwar bus is already developed —and jiggles, bangs, bounces, and bumps are gone. Years ago, B. F. Goodrich engineers realized that, in addition to rubber tires, the shock-absorbing qualities of rubber could be used in springs, too, for greater riding comfort.

Finally, just before the war, they developed a "rubber hip" that suspends an automobile or bus body in soft, cushioning rubber. This device, the Torsilastic spring, is a steel cylinder placed lengthwise to the frame. Inside is a shaft. Space between cylinder and shaft is filled with rubber, attached by permanent bond to both metal surfaces. The weight of the bus gives a slight twisting action to the rubber.

Road shocks are lost in the rubber — they cannot pass through it to the car frame. The result is the "velvet ride" that has been the aim of automobile designing for decades.

War put a stop to use of natural rubber for this new spring. But now enough synthetic rubber has been released by the government to equip new Twin Coach buses badly needed for wartime transportation . . . their passengers will be floating on rubber and sitting pretty.

Some automotive men say the bus developments of today will be on your automobile tomorrow, so the rubber spring for the velvet glide may be on your postwar car — another contribution of B. F. Goodrich research. *The B. F. Goodrich Company, Industrial Products Division, Akron, Ohio.*

B.F. Goodrich

RUBBER *and* SYNTHETIC *products*

"We clean our Compressed Air *Automatically* all over the plant"

Your compressed air operations should be as modern and efficient as your machinery and production methods. That means replacing of antiquated "accumulator and discharger" systems that never *eliminate* oil and moisture with the modern Swendeman method of continuous elimination. You'll get increased efficiency, power and economy, as the following facts prove.

THE OLD WAY

"Traps" that catch moisture, oil and dust, actually put moisture back into the air as soon as air velocity becomes sufficient. Some "traps" rely on "automatic" ball-type closure operation which is subject to rust and failure.

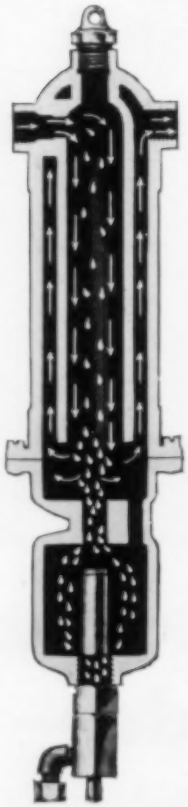
INEFFECTIVE "DRAINING"

Oil and water start accumulating at once when the trap is closed after draining. Thus, your compressed air is never really dry, really clean — and your air operations are almost constantly retarded.

COSTLY INEFFICIENCY

Accumulation of foreign matter in compressed air equipment depending upon trap "elimination" causes decreased pressure, ice formation, rust and spoiled work *all over the plant* — often running into thousands of dollars a year in a single plant.

A large part of our production facilities is devoted to war work. Orders for Swendeman Air Separators will be delivered just as quickly as possible.



THE NEW WAY

The Swendeman Automatic Air Separator is *not a trap*. It is scientifically designed to eliminate all moisture, oil and dust *constantly*, without retarding flow of air or decreasing pressure. No clogging or "plugging" means minimum operating trouble.

CONSTANT ELIMINATION

The Swendeman Separator has expansion chambers connected with an "Eliminator" vented to the atmosphere, which receives oil and moisture and expels it immediately and constantly.

INCREASED PRODUCTION . . . LOWER COSTS

The Swendeman Automatic Air Separator does away with all the costly inefficiency of the old methods of "removing" moisture, oil and dust from your compressed air. It is a most profitable investment. Write for literature.

A-2

SWENDEMAN
Automatic Air Separator
A DEXTER PRODUCT

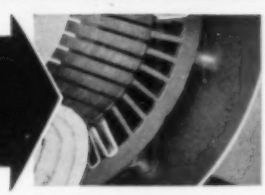
The LEAVITT MACHINE COMPANY
ORANGE, MASSACHUSETTS

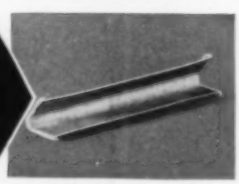
Thorough Insulation of Windings keeps Wagner Motors on the job!

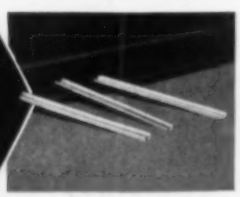
THE windings of Wagner motors are thoroughly insulated with liberal quantities of the highest-quality materials. Wagner engineers will not permit the use of insulation which is barely adequate for ordinary service. They insist that all windings shall be thoroughly insulated so that Wagner motors will render dependable service even under the most severe operating conditions.

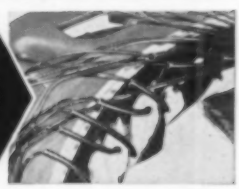
Illustrated and described below are a few of the reasons why the insulation on Wagner polyphase stator windings of the diamond type virtually precludes the possibility of failure.

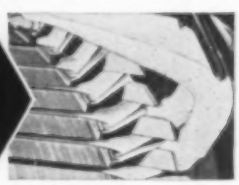
POSSIBLE CAUSE OF GROUND	WAGNER INSURANCE AGAINST GROUND	POSSIBLE CAUSE OF SHORT CIRCUIT	WAGNER INSURANCE AGAINST SHORT CIRCUIT
Slot cell cut by core iron.	Smooth core and slots.	Contact between turns in coils.	Heavy coating of synthetic varnish on wire.
Slot cell torn during winding.	One piece, tough, cuffed slot cell.	Contact between coils in slot.	Heavy, tough separator in slot.
Creepage through mouth of slot.	Inverted cell over coil.	Contact between ends of coils.	Varnished-muslin phase-sheets.
Creepage caused by dirt on winding.	Coils completely taped and varnish-treated.	Contact between coil connections.	Varnished-muslin insulating-tubes.

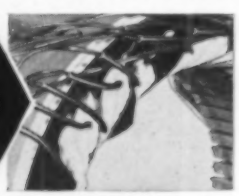












29 BRANCH OFFICES

Wagner maintains 29 branch offices located in principal cities. Each office is manned by trained field engineers who will gladly consult with you.

M 45-5

Wagner

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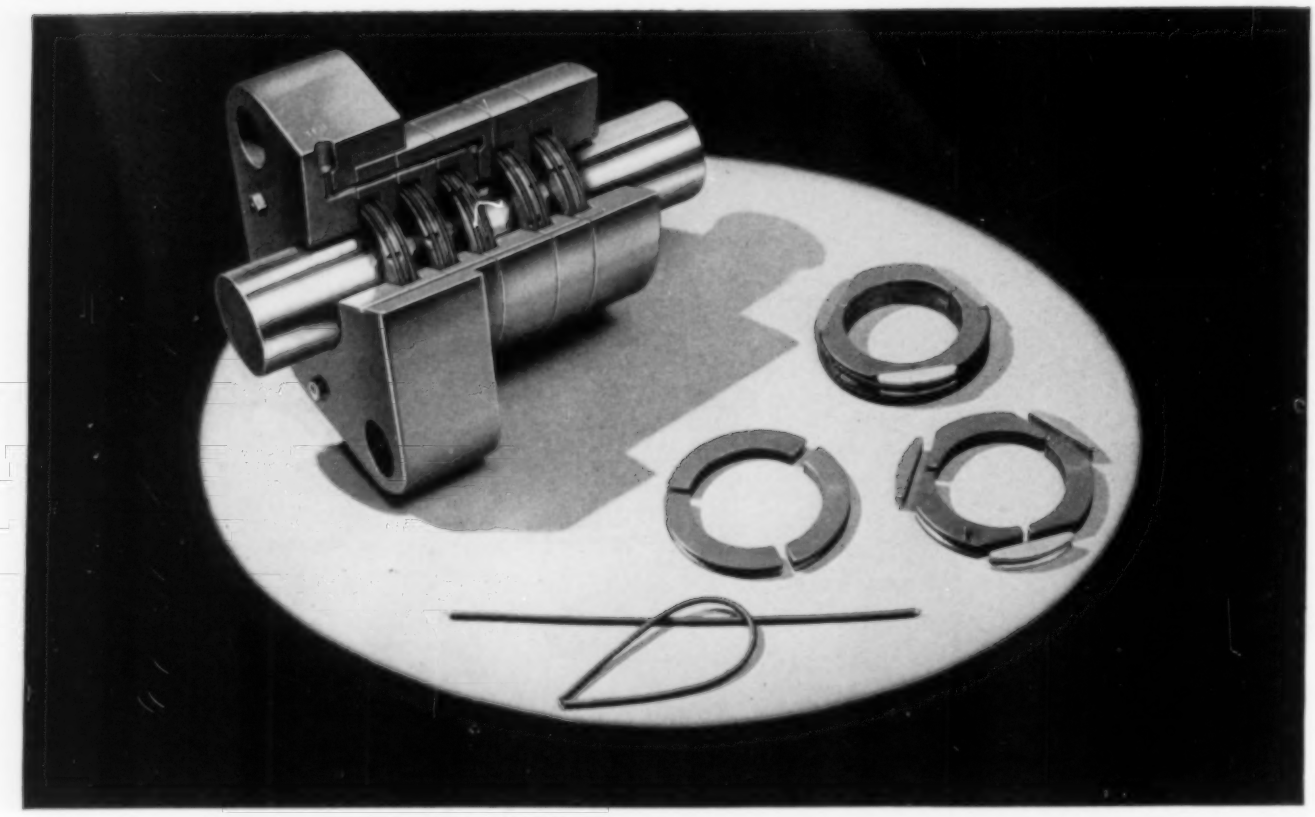
ELECTRICAL AND AUTOMOTIVE PRODUCTS

OTHER WAGNER PRODUCTS

Write for literature on Wagner Motors, Transformers, and Industrial Hydraulic Braking Systems.



PRECISION

COMPRESSOR ROD PACKINGS

MORE HORSEPOWER AT LESS COST is the net result when your engine or compressor is equipped with COOK'S Precision Metallic Packings. Here's why:

Precision construction assures positive seal of the pressure.

Basic design allows for rod misalignment and vibration, without added friction and wear, provides automatic compensation for wear and guarantees a constant oil film between rings and rod.

Regardless of the make or type of your equipment you can have the improved operation and years of repair-free service COOK'S Precision Packings bring, because there is a proved type and material for all prevailing pressures and temperatures. Shown above is the annular cup type.

Many engine and compressor manufacturers supply COOK'S Packings as original equipment—others furnish them on request. So, when ordering new equipment, specify COOK'S Packings.

For equipment in service, write or call our nearest office.

Sealing Pressures Since 1888

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Maintenance time reduced to a minimum

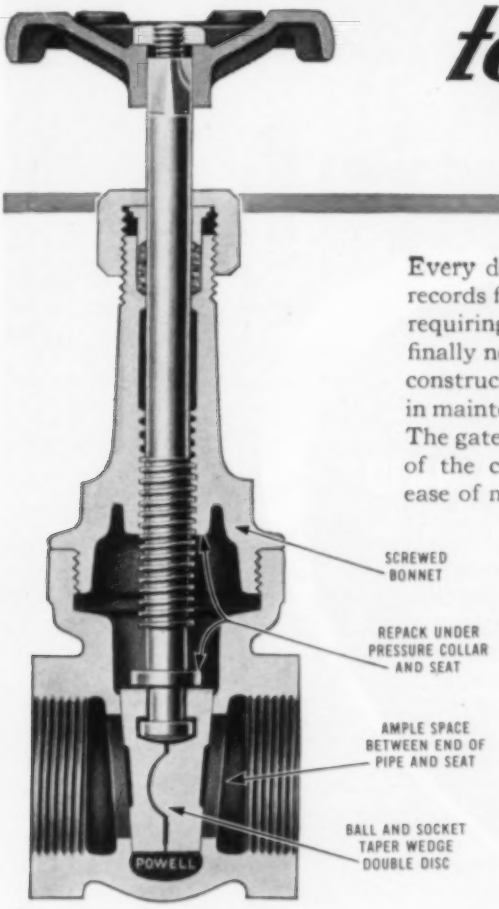
SCREWED BONNET
REPACK UNDER PRESSURE COLLAR AND SEAT
AMPLE SPACE BETWEEN END OF PIPE AND SEAT
BALL AND SOCKET TAPER WEDGE DOUBLE DISC
POWELL

Fig. 500
BRONZE "U. S." GATE VALVE

Every day, Powell Valves are piling up records for continuous operation without requiring maintenance. And when they finally need attention, Powell design and construction is such that the time spent in maintenance is reduced to a minimum. The gate valves shown here are examples of the complete Powell Line in which ease of maintenance is always a feature.

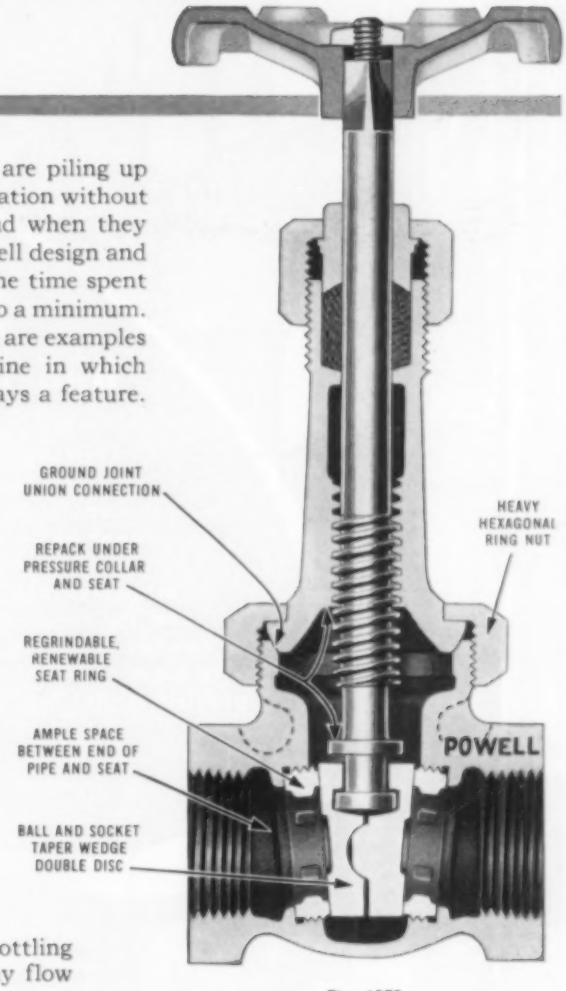
GROUND JOINT UNION CONNECTION
HEAVY HEXAGONAL RING NUT
REPACK UNDER PRESSURE COLLAR AND SEAT
REGRINDABLE, RENEWABLE SEAT RING
AMPLE SPACE BETWEEN END OF PIPE AND SEAT
BALL AND SOCKET TAPER WEDGE DOUBLE DISC
POWELL

Fig. 1375
BRONZE "WHITE STAR" GATE VALVE

In all installations where pressure drop is undesirable and throttling is unnecessary, the gate type of valve, with its full straightway flow area through the body, should be used.

Fig. 500 is Powell's answer to the widespread demand for a sturdy small bronze gate valve where initial cost is a consideration. With its readily removable screwed-in bonnet it is easy to reface the seats and disc or replace the disc if necessary. The taper wedge double disc, with its Powell-designed ball and socket action, readily adjusts itself to any inclination of the seat faces caused by refacing, thus effecting a tight closure. Since the seats are cast integral with the body, this valve will give dependable service as long as sufficient metal remains in the seats to permit refacing.

For *extra long life*, Fig. 1375 is recommended. The ground joint union connection makes it especially easy to remove the bonnet assembly from the body to reface or, if necessary, to replace the disc and renewable seats. This may be done any number of times without any distortion of the body neck, such as might occur with a screwed-in bonnet. Both disc and seats are made from a special hard nickel-bronze alloy which resists wear over a long period of time. When these parts will not take further refacing, they can be readily replaced with new ones, thus greatly prolonging the life of this valve.

All Powell Valves that require repacking are provided with a specially machined cut-off to permit repacking under pressure when wide open.

The Wm. Powell Co.
Dependable Valves Since 1846
Cincinnati 22, Ohio

POWELL VALVES

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HAS THE "KNOW-HOW"
As the pioneer Company in the development and manufacture of silencing equipment, Maxim has experience "plus" to offer in solving your silencing problems. Maxim exhaust and intake silencers, spark arrestors, steam blow-off silencers and the new Heat Recovery silencers are in operation today in industry from coast to coast. When the problem is silencing, consult Maxim.

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THE MAXIM SILENCER CO. • 85 HOMESTEAD AVE., HARTFORD, CONN.

ROEBLING

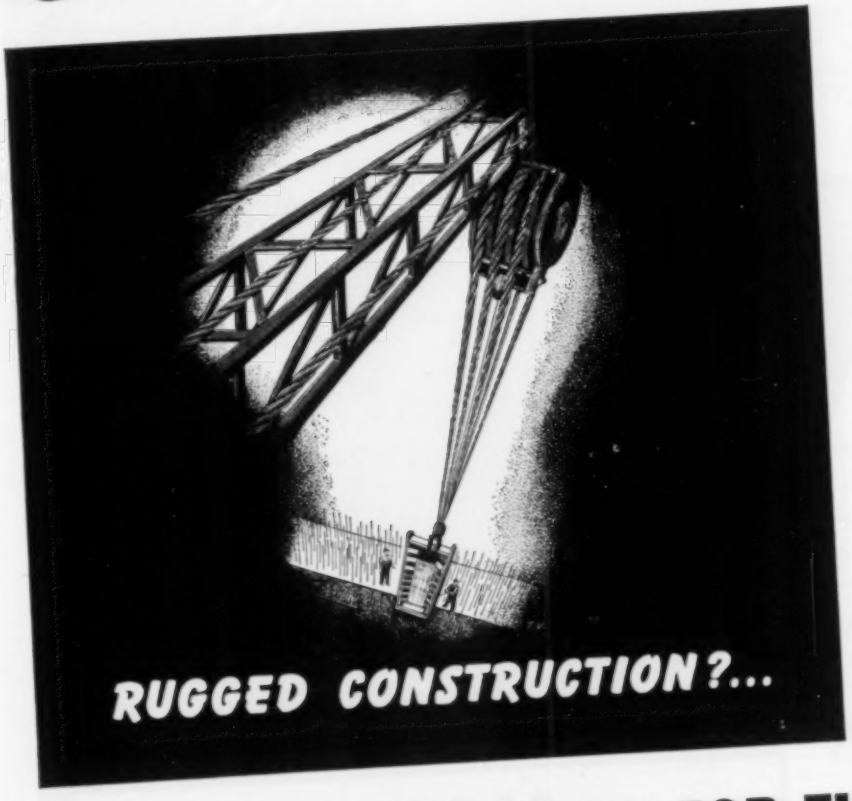
QUESTIONS AND ANSWERS

Q What is meant by the designations of 6x7, 6x19, 8x19, and 6x37 rope?

A **Each of the above designate a particular group or classification of wire rope: the 6x7 rope contains 6 strands of 7 wires each, whereas the 6x19 rope contains 6 strands with from 16 to 25 wires per strand. The 8x19 rope contains 8 strands with from 16 to 25 wires per strand, while the 6x37 rope contains 6 strands having from 26 to 46 wires per strand.**

Q How do the above groups or classifications of ropes compare as to abrasion resistance and flexibility?

A **The 6x7, 6x19, 8x19 and 6x37 ropes are rated as listed with respect to abrasion resistance, the 6x7 having the greatest resistance to abrasion. The flexibility of these ropes follow in the same order with the 6x7 having the least flexibility.**



CHOOSE WIRE ROPE FOR THE LONG PULL!

No TIME to "Baby" your equipment when you've got to keep a heavy flow of construction materials moving at a fast clip. And whether it's shovel or hoist, crane or dragline — efficiency depends on wire rope that has the capacity to *deliver*...day in and day out. That's *why*, when the heat's on to meet construction schedules, you can have confidence in Roebling "Blue Center" Wire Rope ...and it's all-around, built-in *quality*.

Precision-engineered...to combine strength and flexibility with fatigue-and-abrasion resistance to best advantage for the job. Roebling "Blue Center" Wire Rope reduces maintenance problems, expensive stoppages... and operation costs.

And remember that Roebling, with a century's background of wire specialization, can help you choose the *right rope for your job*. Check with our nearest branch office, and get started on the way to increased output from your rope-rigged equipment. Our wire rope engineers are always at your service.

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TRENTON 2, NEW JERSEY

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WIRE ROPE AND STRAND • FITTINGS • SLINGS
ELECTRICAL WIRES AND CABLES • COLD ROLLED STRIP
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CABLES • HIGH AND LOW CARBON ACID AND BASIC
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JR ROEBLING

PACEMAKER IN WIRE PRODUCTS

ADV. 30

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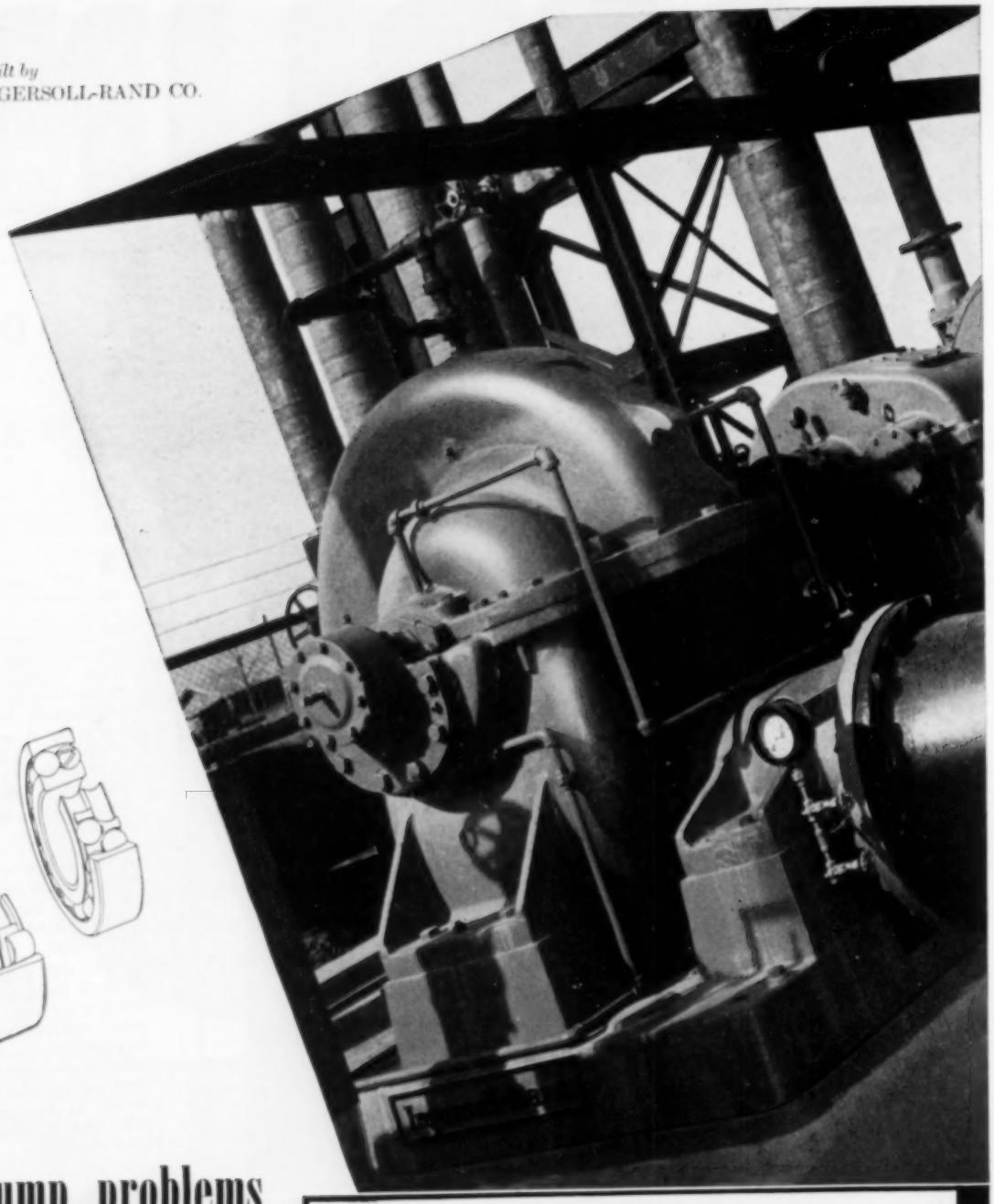
INGERSOLL-RAND CO.



Easing pump problems

The wisdom of using SKF Bearings on this single slate water supply pump, one of ten in a Butadiene plant, has been proved in many ways. It's proved in smooth day-and-night operation . . . in the ability of SKF's to bear the brunt of heavy loads . . . in SKF's built-in alignment to compensate for the difference in expansion and contraction between the pump shaft and casing. Dependable bearings and dependable pumps go together. 5774

SKF INDUSTRIES, INC., PHILA. 34, PA.

SPECIFY

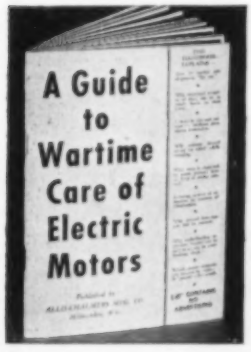
SKF

BEARINGS

FIRST AID FOR MOTORS

MOTORS RUN A FEVER? No wonder if they do more often today. They're working *3 and 4 times* as many hours as in peace!

Wartime conditions demand you diagnose motor ailments *quickly* . . . remedy the trouble at once. At right are but few of the many diagnoses found in Allis-Chalmers' new "Guide to Wartime Care of Electric Motors". In maintenance as in war, *attack is the best defense.* This book singles out the 9 main enemies of electric motors . . . tells you how to get them *before* they get your motors!



Over 100,000 copies already in use.

Write today for your *free* copy. ALLIS-CHALMERS MFG. CO., MILWAUKEE 1, WIS.

SYMPTOMS YOU CAN *SEE*

Symptom	Possible Causes	Cure
1. Excessive sparking or flashing at brushes. Blackened commutator.	Rough commutator.	Sand or turn down, depending upon depth of surface roughness.
	Low bar on commutator.	Grind or turn down balance of commutator.
	High bar on commutator.	If extreme, lower with mallet, tightening clamping ring. Grind true.
	Brushes too short.	Replace with harder grade—if worn too soon . . . and not by rough commutator.
	Shorted armature winding.	Test for short—after removing metallic contact between commutator bars. Repair.
2. Intermittent sparking at brushes.	Open armature winding.	Locate and replace bad coil—or repair defective joint.
3. Motor won't start.	Usually line trouble.	Correct. Check source of power supply.
	Load too heavy. See if motor runs without load.	Reduce load—or replace motor with unit of greater capacity.

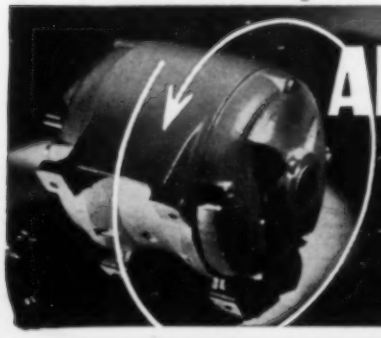
SYMPTOMS YOU CAN HEAR

4. Excessive hum.	Uneven air gap. Measure with feelers.	Replace bearings—before introduction of scraping noise indicates rotor is rubbing.
	Unbalanced rotor. Check on parallel bars.	Balance with solder on band—or weight attached by cap screw and lock washer.
5. Regular clicking.	Matter in air gap.	Take out rotor; remove matter.
6. Rapid knocking	Misalignment.	Realign set until knocking disappears.
7. Brush "chatter."	Extreme vibration.	See item 10, below.

SYMPTOMS YOU CAN *FEEL*

8. Vibration.	Misalignment.	Realign set.
	Vibration in driven machine.	Eliminate source in machine, if possible. Or a flexible belt drive may be in order.
9. Motor overheating. (Check with thermometer—don't depend on hand).	Overload. Measure load; compare with nameplate rating.	Check for excessive friction in motor, drive or machine. Reduce load, or replace motor with greater capacity unit.
	Dirt in motor. Check flow of air.	Blow out motor. Use solvent on wound section if necessary.
	Rotor rubs stator.	Replace bearings.

A 1638



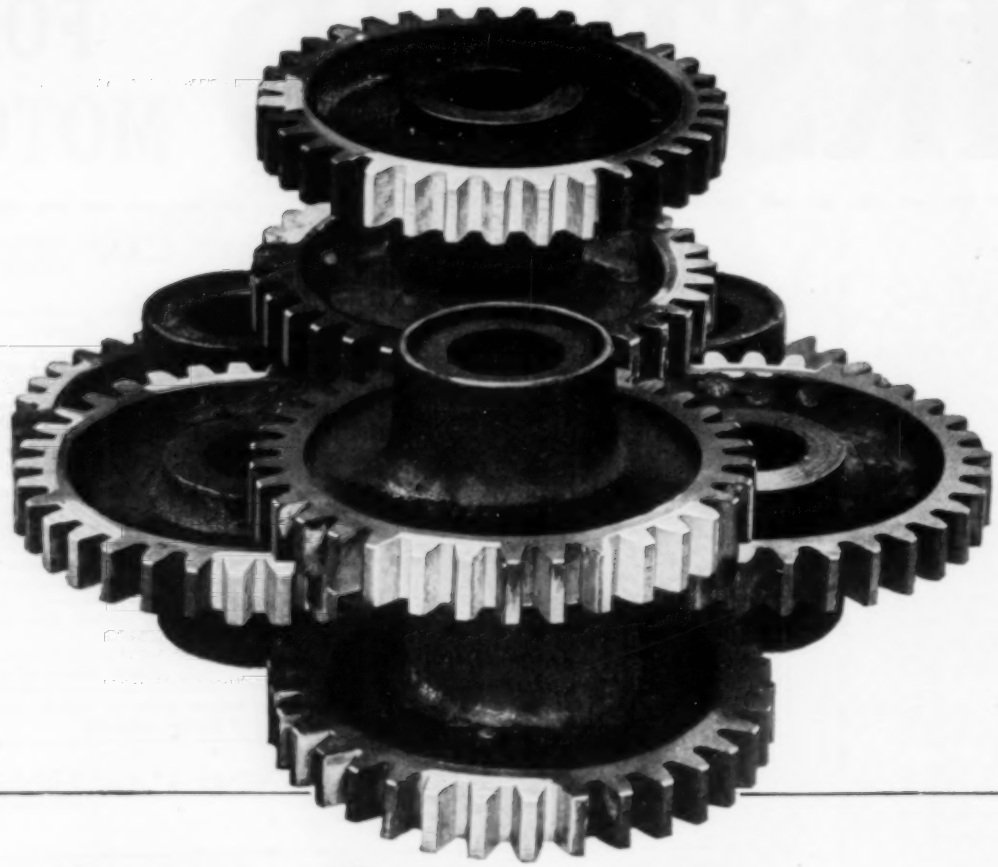
ALLIS-CHALMERS MOTORS

When you do need new motors, look into the strength, solidity and all-around protection of the new "Safety Circle"—protected top, sides, ends and bottom.

AC

WE WORK FOR VICTORY

WE PLAN FOR PEACE



Spare Gears... Tobin Bronze Welded

eliminate down-time on war jobs

READY TO GO to work again, this group of worn and broken gears from wire braiding machines at the Metal Hose Branch of The American Brass Company, were quickly and economically reconditioned with Tobin Bronze* Welding Rod.

Through the use of these spare gears, the machines were kept in operation 24 hours a day on vital war work, braiding wire over flexible metal tubing for ships, tanks, aircraft and landing craft.

"Don't Scrap It... Bronze Weld It!" is more than a slogan—it's a NECESSITY in many plants. Publication B-13 describes Anaconda Welding Rods, suggests uses and procedures. Write for a copy. 45104

*Reg. U. S. Pat. Off.

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

ANACONDA

BUY WAR BONDS... Buy All You Can... Keep All You Buy!

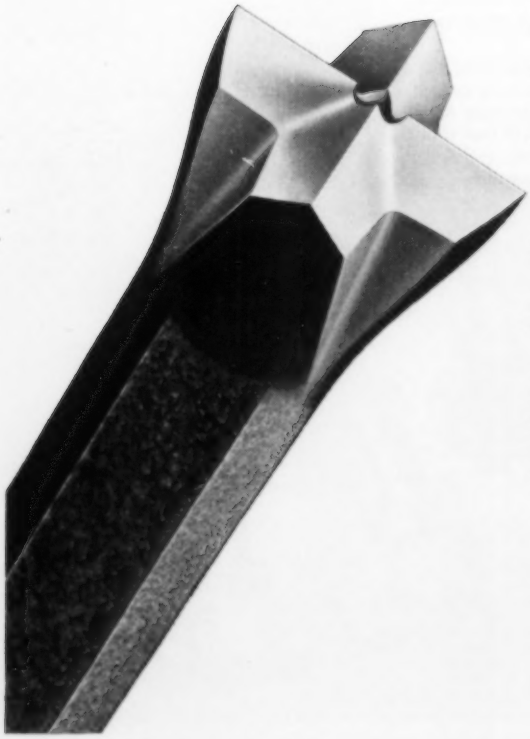
Anaconda Bronze Welding Rods

3 VIEWPOINTS ON SUPERIOR HOLLOW DRILL STEEL

THE DRILL RUNNER SAYS:
"I like this hollow steel because it holds its edge better, cuts fast, and gives me top footage."

THE BLACKSMITH SAYS:
"I like it because it makes up easily, has a wide quenching range, and gives a better hardness under heat-treatment."

THE METALLURGIST SAYS:
"The analysis looks good and the balanced grain structure reduces progressive fatigue failure."



Three separate viewpoints, but all of them mighty important where there's rock to be drilled. The drill runner, the blacksmith, and the metallurgist like Bethlehem Superior for different reasons, but essentially all the reasons boil down to this single point: *Faster drilling at lower cost.*

Bethlehem Superior is tough, resilient, shock-resisting—yet sufficiently deep-hardening to produce a shank that withstands the punishing blows of the piston. It's a hollow steel that's equally suitable for both forged-on bits and fabricated rods used with detachable bits.

Like most mining and contracting men, you're probably well acquainted with Bethlehem Superior. If not, ask your Purchasing Department for some of it when you need your next drill steel. After that, we think you'll be calling for it all the time.

★ BETHLEHEM STEEL ★

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valves and fittings

DISTRIBUTORS IN PRINCIPAL CENTERS
THROUGHOUT THE WORLD

SINCE 1842 Walworth has continuously manufactured valves and fittings for every need. Its complete line of products includes:

STEEL VALVES: Made in all styles and sizes for pressures up to 5000 psi OWG — 1500 psi Steam at 950F.

BRONZE VALVES: Gate, Globe, Angle and Check types for services up to 3000 psi OWG — 300 psi Steam at 500F.

LUBRICATED PLUG VALVES: Plain and ball-bearing types, ½" to 24", for pressures from 125 to 5000 psi and vacuum.

FITTINGS: A complete line in steel, bronze, and iron. Screwed, flanged, and welding ends.

WALSEAL* VALVES AND FITTINGS: For making threadless Silbraz* joints on copper or brass pipe or tubing. * Reg. Trade Marks

PIPE WRENCHES: Three types—Walco, Walworth Genuine Stillson, and Parmelee—each one strong, simple and dependable.

12 AWARDS
TO 4 PLANTS

For a detailed description of Walworth products, write on your company letterhead for free copy of Catalog 42. Address the Walworth Company, 60 East 42nd St., New York 17, New York.

Easier TO USE

....that's why they choose AIR TOOLS

Here are several reasons why operators find air tools easy to handle:

- They are about one-half the size of other types of portable power tools. Consequently, they are lighter in weight. This means that operator fatigue is kept at a minimum.
- Air motors cannot be damaged by overloading. This feature, plus sturdy construction, assures trouble-free service.
- Workers can produce more work with less effort because air tools deliver more power per pound of weight.
- Power regulation permits the use of air tools on many kinds of materials and many types of operations.
- Starting and stopping are practically instantaneous. Air tools give maximum power immediately.
- Compressed air is the safest method for the transmission of power for portable tools. Air tools are safe.

Ingersoll-Rand

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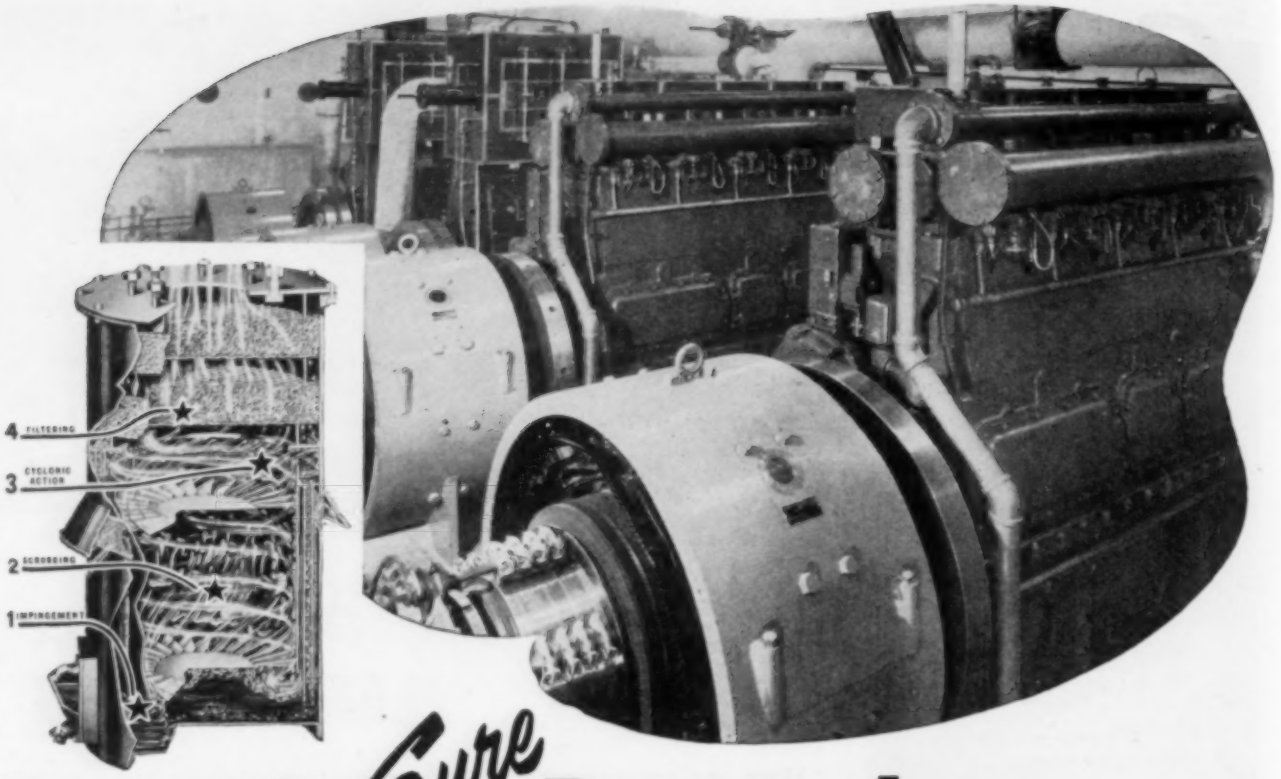
8-550

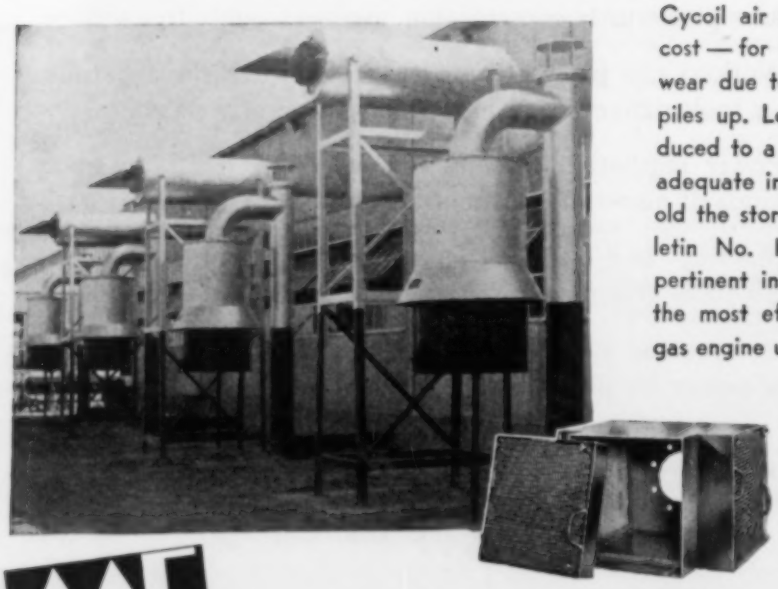
Air Motors	Hoists	Rock Drills	Sump Pumps
Calking Hammers	Nut Runners	Sanders	Tampers
Concrete Vibrators	Reamers	Sand Rammers	Tappers
Drills	Rivet Busters	Scaling Tools	Wood-Borers
Grinders	Riveting Hammers	Spades and Diggers	Impact Wrenches

Industrial Air Compressors for Every Service



Provide *Sure* Protection

AGAINST EXCESSIVE WEAR AND BREAKDOWNS



Cycoil air cleaner protection is cheap at many times its cost — for when break downs occur caused by excessive wear due to the abrasive action of dust — expense really piles up. Losses caused by shut downs for repair are reduced to a minimum if power equipment is provided with adequate intake air cleaning. Whether engines are new or old the story is the same. — May we send you Cycoil Bulletin No. 130-D which gives engineering data and all pertinent information? Cycoil is universally recognized as the most efficient air cleaner yet devised for Diesel and gas engine use.

PROTECT COMPRESSORS, TOO!

Type OC-H filters are ideal for compressor service. Come as complete assemblies of viscous impingement type cells and housings. Installation consists merely of bolting housings to flange on air intake pipe. Send for Bulletin 130-D for complete information.

AAF

AMERICAN AIR FILTER COMPANY INC.

INCORPORATED

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Fresh Oil

DROP BY DROP UNDER PRESSURE

from six popular models for every application. The most dependable method of lubrication ever developed. Madison-Kipp specializes in lubricators for original Standard equipment. Write for special engineering data for your particular requirement.

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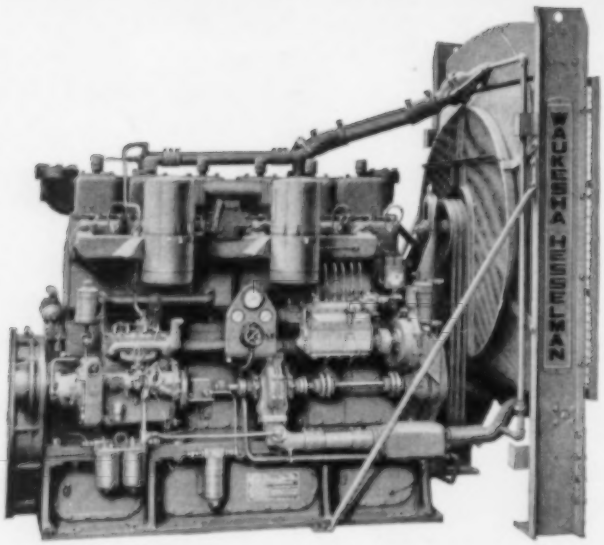
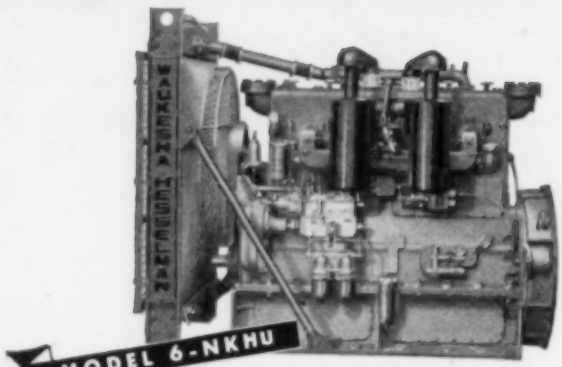
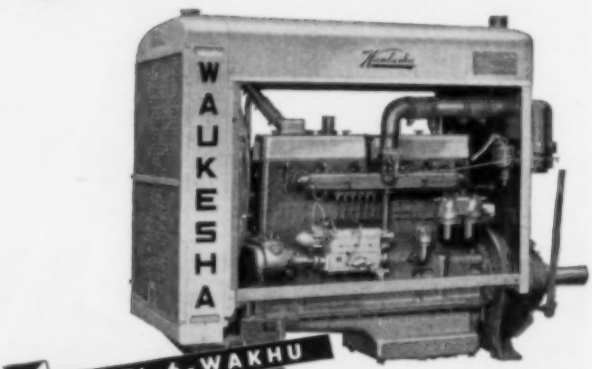
HESSELMAN *Oil* ENGINES



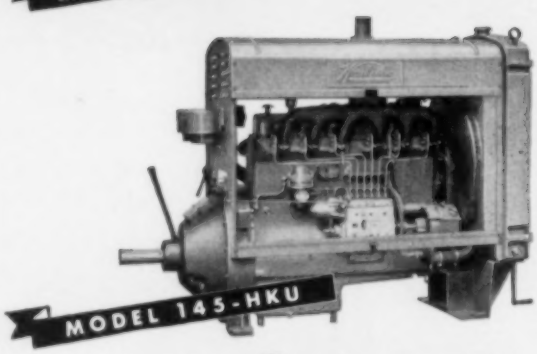
MODEL 6-LRHU



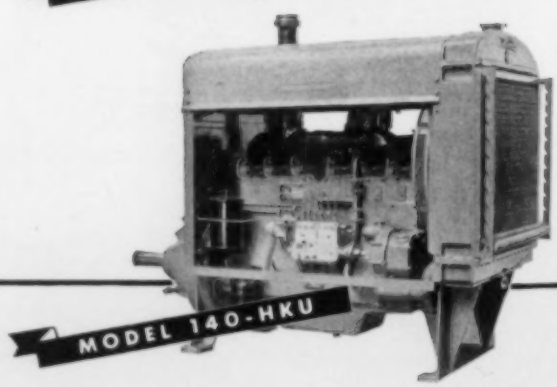
MODEL 6-NKHU



MODEL 6-WAKHU



MODEL 145-HKU



MODEL 140-HKU

In wartime every Waukesha Engine is a war-work engine. All Waukesha production is for the use of the armed forces. Until the war is won, Waukesha postwar engine designs are not being shown.

But peacetime models are on the way. New advantages and greater user conveniences will make the new peacetime Waukesha-Hesselman *the world's most wanted diesel-oil engine.*

After the war the fuel problem for engine-driven equipment will be serious *unless it is Hesselman powered.* Because it burns those widely sold Nos. 1, 2 or 3 domestic furnace oils as well as high-speed diesel fuels . . . either high or low cetane. . . Hesselman will be the operator's first choice for country-wide use. And a Hesselman may be converted from fuel injection to carbureted gas or gasoline without changing a single major part. *No compression ignition Diesel can be converted from fuel oil to gas or gasoline so quickly, or easily.* Even gasoline injection is possible with the Hesselman.

And Hesselman's *electric and positively timed ignition* and lower pressures give easier starting, less shock load, longer life, lower upkeep than with any other diesel-oil engine.

For your future engine needs, consult Waukesha now. Get Bulletin 1341

Power Unit Model	No. of Cyls.	Bore and Stroke, In.	Displ. Cu. In.	Speed RPM
*130-HLU	4	4 x 5	251	1000-2000
*VRZHU	4	4 5/8 x 5 1/4	353	1000-1600
*140-HKU	6	4 1/2 x 5 1/2	525	1000-1800
*145-HKU	6	5 1/4 x 6	779	1000-1800
6-WAKHU	6	6 1/4 x 6 1/2	1197	800-1600
6-NKHU	6	7 x 8 1/2	1962	750-1200
6-LRHU	6	8 1/2 x 8 1/2	2894	750-1200

*These Hesselman Engines are true *multi-fuel engines*, and can be converted to burn natural gas or gasoline, with no internal changes. The others can also be converted provided manifolds for carbureted fuels are applied.

WAUKESHA MOTOR COMPANY, WAUKESHA, WIS.

NEW YORK • TULSA • LOS ANGELES

- *Insoluble*—Stays put; will not wash out
- *Seals Permanently*—Fills all clearances and imperfections
- *Lubricates threads*—Permits quick and easy tightening
- *Eliminates galling, rust*—Joints easily taken apart later
- *Never hardens*—Can't crack under vibration or strain
- *Ready for use*—Packed in 1, 5 and 7 lb. cans

John Crane Plastic Lead Seal is ONE compound for ALL general services. Use it for plant maintenance and production assembly. A test tells the full story. Write us—sample will be sent immediately.

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CRANE PACKING CO., LTD., Hamilton, Ontario, Canada.
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DON'T GIVE UP THE SHIPS

FROM the days of John Paul Jones and the *Bon Homme Richard* America has taken a just pride in her Navy. But two modern wars have shown us that merchant ships are as vital to our national safety as fighting ships. Twice in our history we've had a fine merchant marine. And each time we lost it. No enemy took our ships from us — *we gave them up.*

In the 1830's nine-tenths of our foreign trade was carried in American ships. But national apathy brought about a complete reversal, and by 1910 foreign ships were carrying nine-tenths of our foreign trade.

At the outbreak of World War I we frantically began building up our depleted merchant marine to transport urgently needed troops and supplies. And at the close of the war American ships were carrying 11 million gross tons annually.

But again we allowed our strength in merchant shipping to deteriorate, and by the middle thirties foreign ships were carrying 75 per cent of our foreign trade, and millions of dollars that should have gone to American shipping and seamen were paid to foreign shipping interests.

Today — thanks to the U. S. Maritime Commission and our vast shipbuilding industry — we have by far the largest merchant marine in the world and an estimated post-war fleet of over 50 million deadweight tons. This time we cannot afford to lose it — not merely because it will have cost us 18 billion dollars, but because it means the maintenance of our economic and military safety in the post-war world.

For the Merchant Marine, now hastening the day of victory, will also help to expand our foreign trade, maintain our productive capacity, provide post-war employment and preserve our national standard of living. This time, let's not give up the ships, for only national apathy and lack of foresight can take them away from us. Let's preserve *the American Merchant Marine.*

★ ★

It has been the privilege of Combustion Engineering to supply marine boilers for many hundreds of American cargo vessels and tankers. This organization pledges the continuance of its best efforts for the maintenance and upbuilding of the American Merchant Marine so that it may remain second to none in size, speed and efficiency. We believe this objective deserves the interest and support of every American citizen. A-855

C-E INSTALLATIONS span the entire range of steam generating requirements from small stoker-fired boilers of less than 50 horsepower to the largest power station units.

COMBUSTION ENGINEERING

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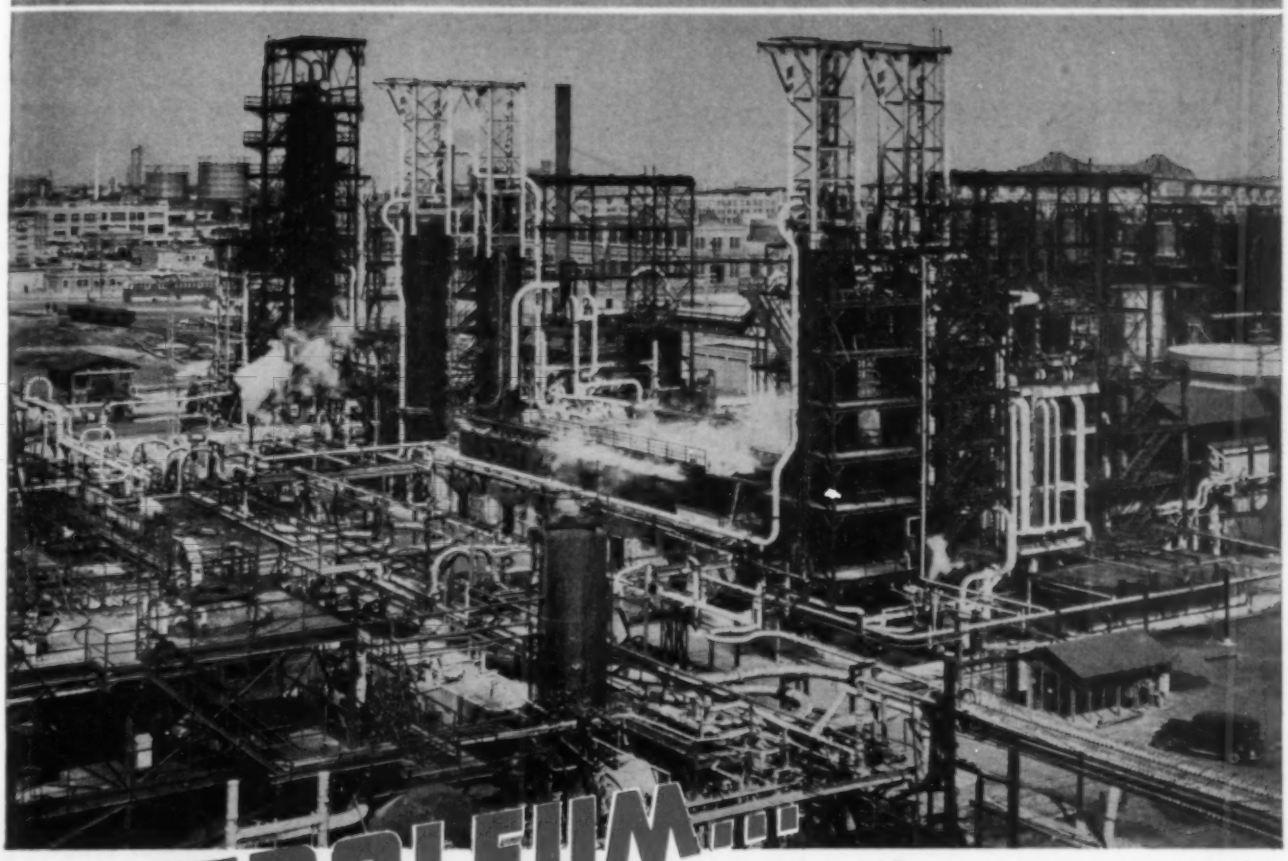
American industry flows through fairbanks valves



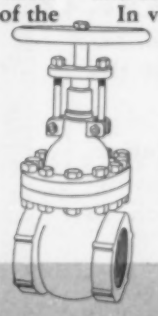
PETROLEUM...

super-servant of industry

In fantastic mazes of piping and tanks . . . in silvery towers and glistening spheres . . . petroleum is broken down to serve industry with an almost unbelievable variety of products and ingredients. Its versatility appears limitless. What other man-perfected gift of nature, for example, can fuel a vehicle, lubricate it, and supply the synthetic for its smooth-running tires?

Operations must run smoothly in every phase of the oil processing industries in which petro-chemistry has scored so many technological advances. Close control of the flow of liquids and gases is all-important and accounts for the unusual care with which valves for such pipelines must be selected.

"American industry flows through Fairbanks valves", and wide refinery use affords a good illustration. One type serving the oil and gas fields is the iron body bronze-mounted gate valve below. Other Fairbanks valves recommended for use in the petroleum industries as well as on steam, gas, water and process liquid lines in all industries are all-iron gate valves as well as bronze valves in gate, globe, angle, and check types.



In valves as in all heavy-duty equipment, there's no substitute for substantially-built units made to close tolerances from metals that are rigidly controlled. There's no substitute for experience such as Fairbanks has gained over its fifty year span of service. For your reference files, write for a Fairbanks Catalog 42, which gives specifications and prices. With it, we'll send nearest distributor's name.

THE fairbanks COMPANY

393 LAFAYETTE STREET, NEW YORK 3, N. Y.

520 Atlantic Ave., Boston 10, Mass. 748 M & M Bldg., Houston 2, Texas 15 Ferry St., Pittsburgh 22, Pa.

This "Arctic Exploration" discovered better piston packing cups

A transplanted polar region played an important part in the development of Wabco piston packing cups for pneumatic and hydraulic cylinders.

In this cold room, so frigid that workers dress like stratosphere fliers, Wabco packing demonstrated its ability to retain resilience, mechanical strength, and sealing properties under extremes of temperature far greater than are ever expected in actual industrial service.

In addition to their staying powers, Wabco packing cups offer an important mechanical feature. The built-in limited compression feature, available in 1-inch to 7½-inch sizes, assures low friction of the packing against the cylinder wall.

Wabco packing cups for original installation in hydraulic and pneumatic cylinders are available in 363 sizes, ranging from ¾-inch to 30-inch.

Westinghouse Air Brake Co.
Industrial Division - - - Wilmerding, Pa.

AIR HOSE That Gives You *Extra* Service and Safety

GOODALL Air Hose is made in several types of moulded-and-braided and wrapped duck constructions, for all light and heavy duty pneumatic tool service. "Subway", "Mine King," "Allgood Cord" and "Oil King" . . . some all-Synplastic . . . are among the brands specified by contractors who demand the best.

Contact Our Nearest Branch or Main Office for Details.

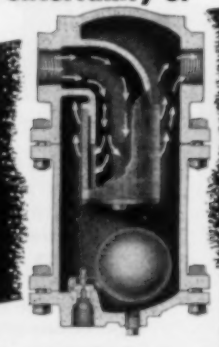
GOODALL
RUBBER COMPANY INCORPORATED

The Goodall-Whitehead Companies
Philadelphia. Trenton. New York. Chicago. Pittsburgh. Boston.

GOODALL RUBBER CO. of CALIF. Factory - Trenton, N. J.
GOODALL RUBBER CO. of TEXAS Established 1870

✓Eliminates need for external traps
✓Ends the bother and uncertainty of manual draining

The NEW Johnson SELF DRAINING Compressed Air Separator



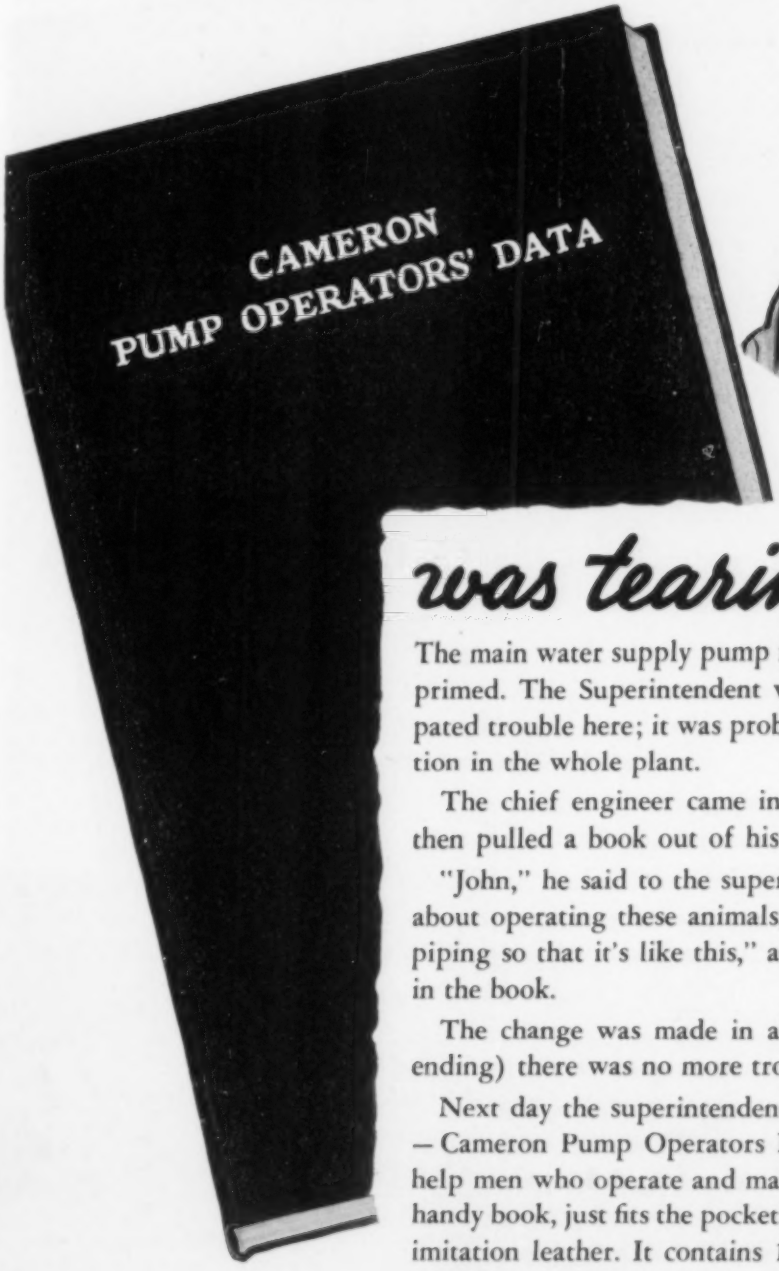
•Here is the time-proved Johnson Separator with a complete trap mechanism built right in—today's newest idea in Separator design. It combines the two best principles of separation—first allows the air to expand slightly, then changes direction of flow abruptly many times with the "thousand baffles"—removes more than 99% of water, dirt and oil. The simple trap mechanism, mounted on bottom plate for easy access, releases the accumulated moisture from the Separator, automatically, whenever necessary.

Johnson Separation Devices include Separators for Compressed air or Steam, After Coolers, Oil Absorbers.

WRITE FOR CATALOG

The Johnson Corporation
830 WOOD STREET THREE RIVERS, MICHIGAN

THE SUPER .....



was tearing his hair

The main water supply pump for the new plant refused to stay primed. The Superintendent was "wild." No one had anticipated trouble here; it was probably the simplest pump installation in the whole plant.

The chief engineer came in — watched a few minutes, and then pulled a book out of his pocket.

"John," he said to the superintendent, "I don't know much about operating these animals, but why don't you change the piping so that it's like this," and he pointed to an illustration in the book.

The change was made in about half an hour and (happy ending) there was no more trouble.

Next day the superintendent wired for a copy of that book — Cameron Pump Operators Data. This book is designed to help men who operate and maintain centrifugal pumps. It is a handy book, just fits the pocket, and it is durably bound in black imitation leather. It contains 170 pages, each one jam-packed with know-how for the pump man.

You may have a free copy. Just request it on your company letterhead. Ingersoll-Rand Company, Cameron Pump Division, 11 Broadway, New York 4, N. Y., or any branch office.

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y.

CAMERON PUMP DIVISION

10-626

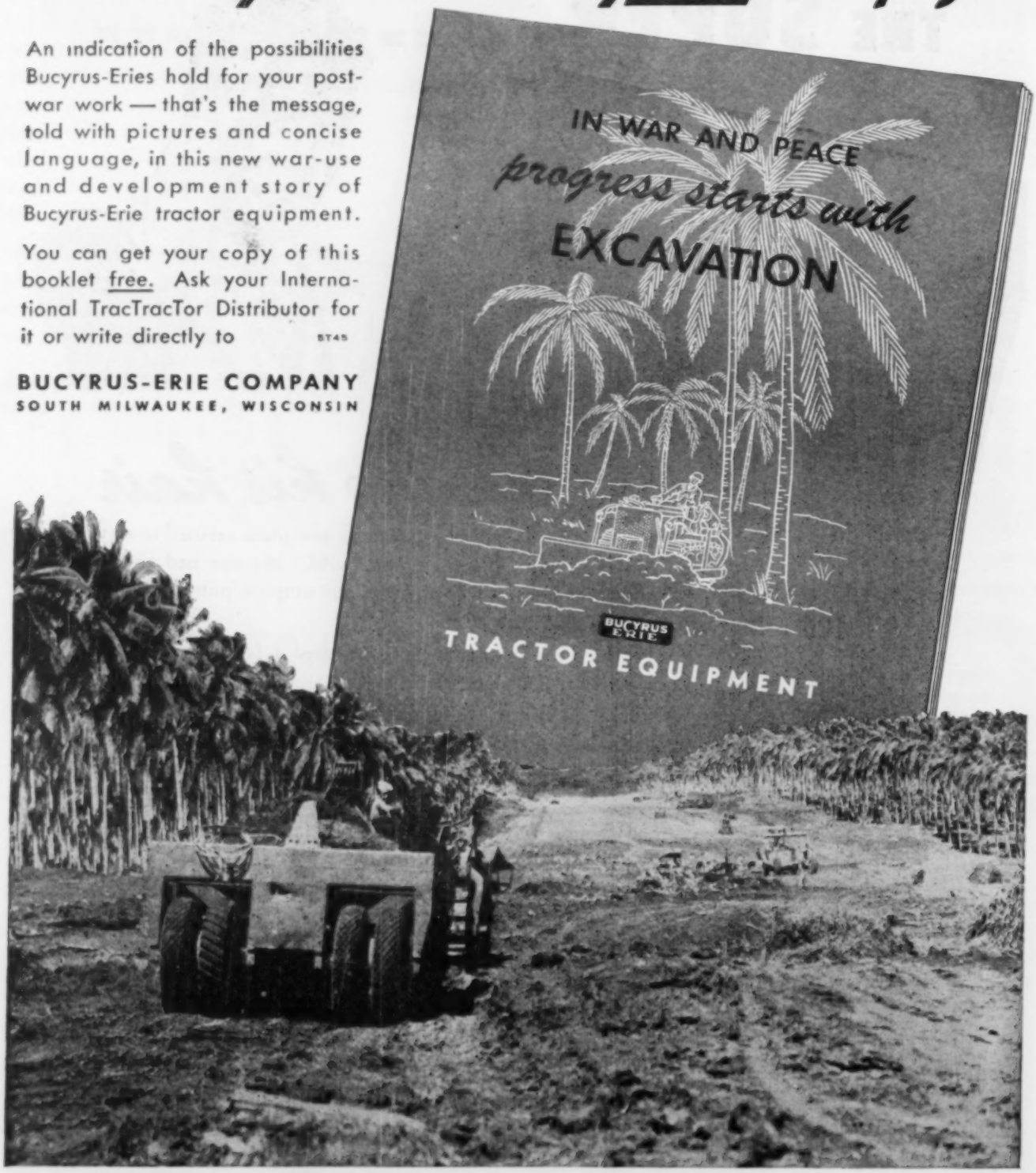
COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO-BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • OIL AND GAS ENGINES

Have You Seen Your Copy?

An indication of the possibilities Bucyrus-Eries hold for your post-war work — that's the message, told with pictures and concise language, in this new war-use and development story of Bucyrus-Erie tractor equipment.

You can get your copy of this booklet free. Ask your International TracTracTor Distributor for it or write directly to BT45

BUCYRUS-ERIE COMPANY
SOUTH MILWAUKEE, WISCONSIN

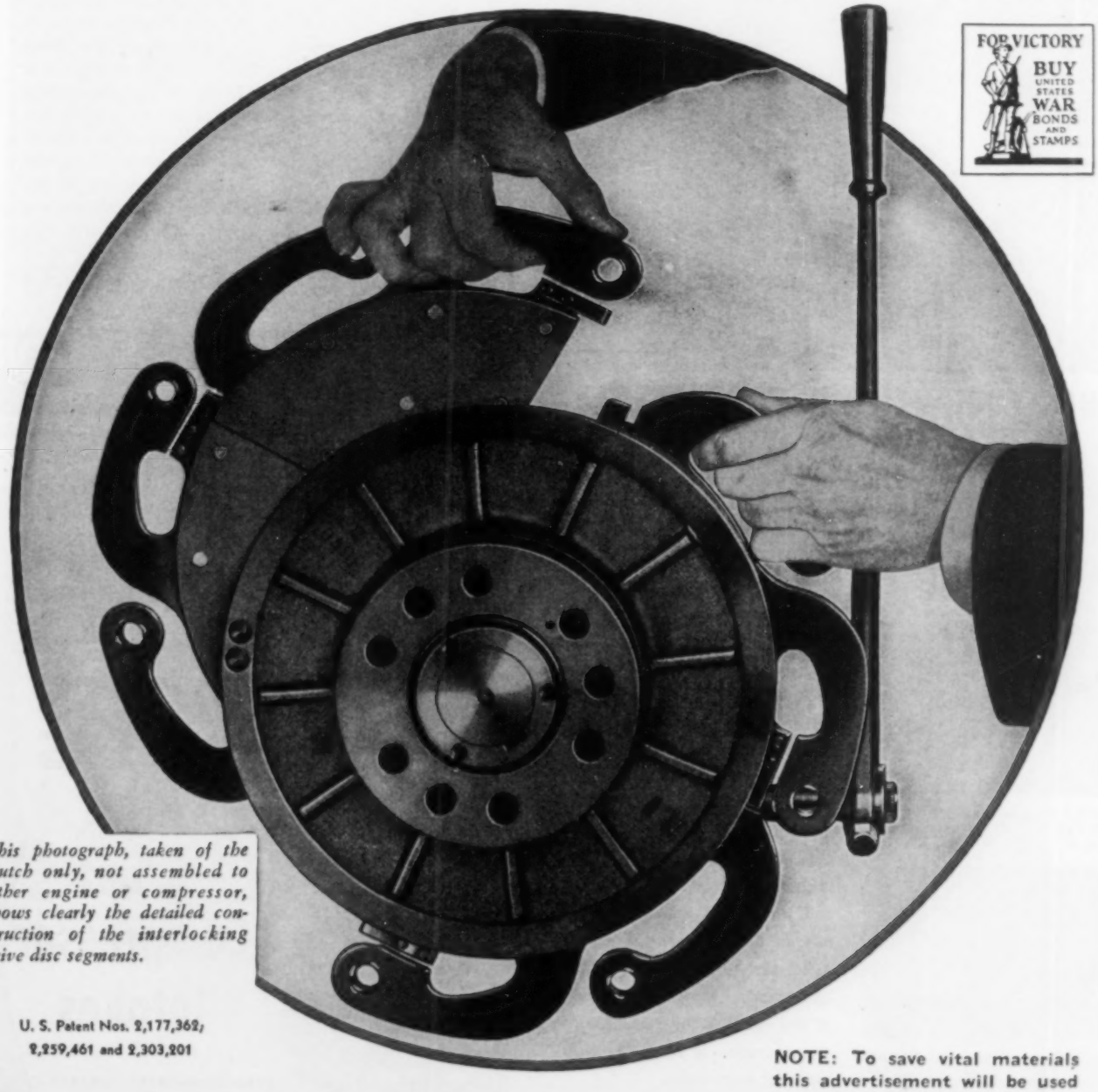


BUCYRUS ERIE TRACTOR EQUIPMENT

SEE YOUR INTERNATIONAL TRACTRACTOR DISTRIBUTOR

FLEX-DISC CLUTCHES

Used on the entire line of I-R *Mobil-Air* Compressors, have a time proven drive disc with flexible fingers solidly bolted to the fly wheel. When the friction facings become worn these drive discs, which are quickly detachable in segments, may be removed and relined or replaced without disconnecting the engine from the compressor.



This photograph, taken of the clutch only, not assembled to either engine or compressor, shows clearly the detailed construction of the interlocking drive disc segments.

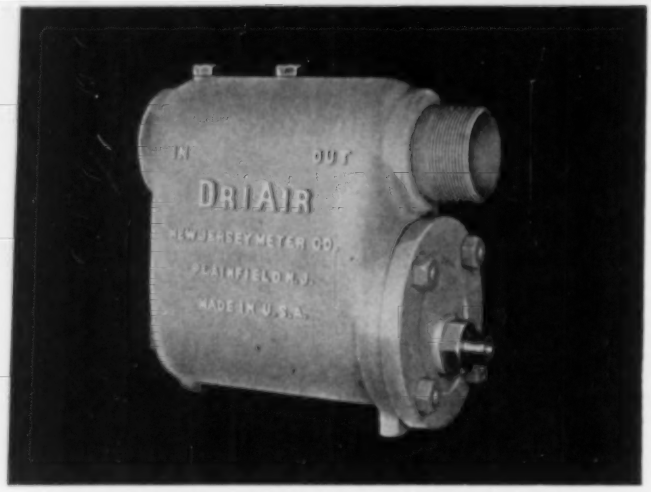
U. S. Patent Nos. 2,177,362; 2,259,461 and 2,303,201

NOTE: To save vital materials this advertisement will be used for "the duration."

C. M. EASON, INDUSTRIAL CLUTCH CO.

Waukesha Wisconsin

DEPENDABLE PNEUMATIC SERVICE



WHEN EQUIPMENT IS PROTECTED BY DRIAIR

A COMPLETE SELF-CONTAINED UNIT

DriAir may be installed by suspending it from the piping without any other support.

A typical installation showing DriAir standing on the floor next to the wall.

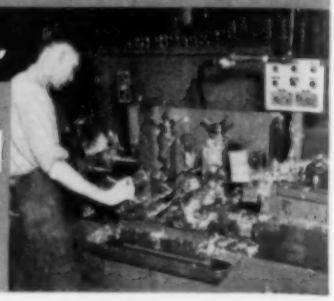
The answer to many problems which arise in various applications of compressed air, DriAir speeds production by separating and automatically ejecting the condensed water and oil from the air. DriAir collects dirt and rust from the air lines and delivers clean dry air to the tools, thus reducing wear and prolonging their life. All internal parts are made of bronze or copper—resistant to corrosion and practically permanent. Copy of Bulletin DA fully describing the operation of DriAir sent on request; write today.

NEW JERSEY METER COMPANY

PLAINFIELD, NEW JERSEY

DIAMOND-BORED RODS

another "HIDDEN VALUE" in all WISCONSIN Air-Cooled ENGINES



Absolute uniformity and close-tolerance fit of all connecting rod bushings are direct results of the unique machine operation illustrated above. Each rod is rigidly locked in precisely the same position, and diamond-pointed bits machine both ends of every rod with uncanny smoothness and perfect mechanical precision. All of this helps to produce a quiet, smooth-running engine, designed and built for heavy-duty service all the way through.

All of this adds up to highly satisfactory *end use* on your equipment.

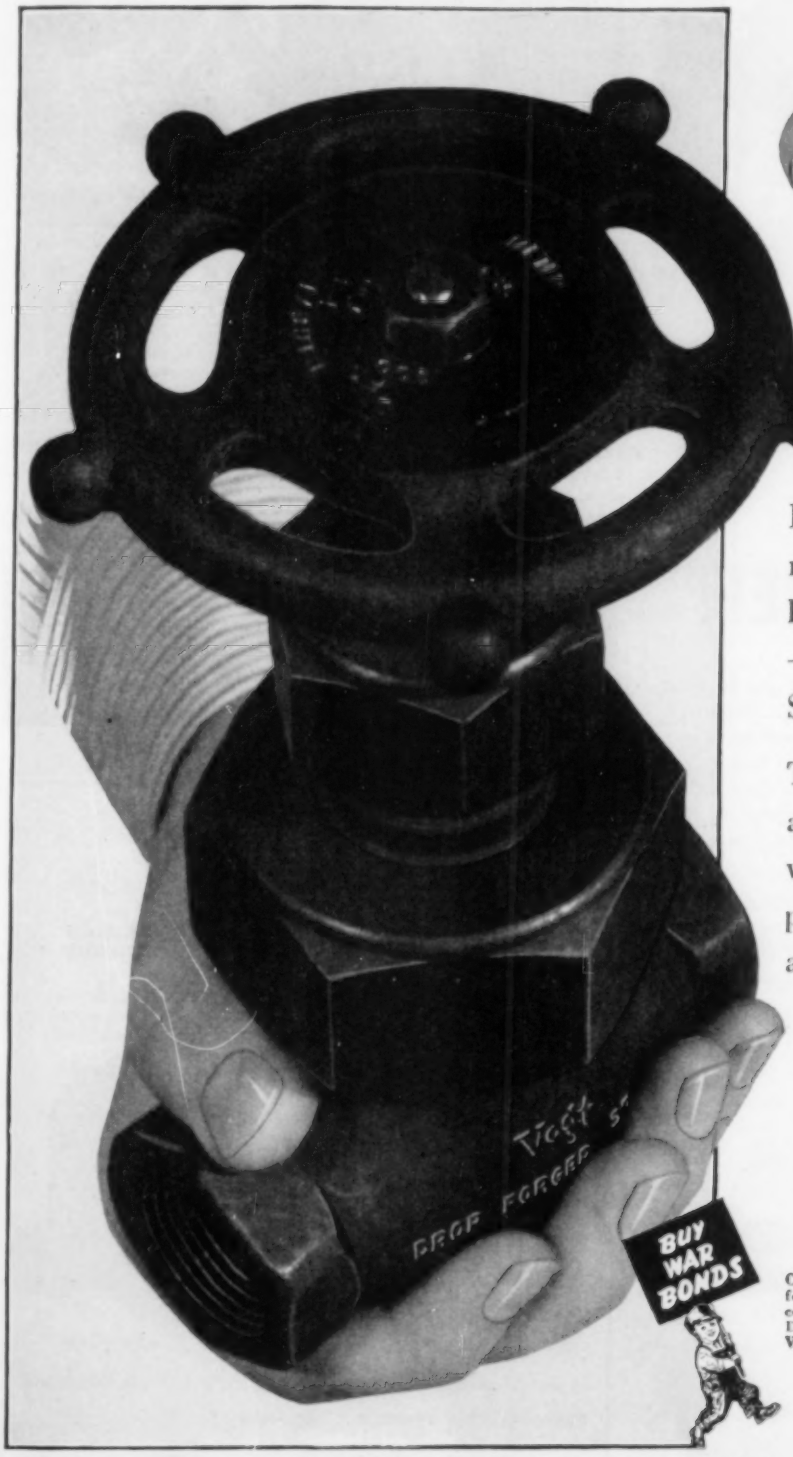
Most H.P. per pound

WISCONSIN MOTOR Corporation

MILWAUKEE 14, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

TODAY LOOK FOR THIS

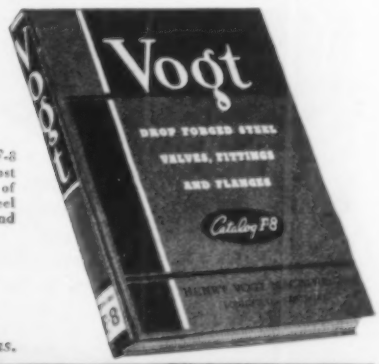


KNOBBED HANDWHEEL*

In high octane gasoline, synthetic rubber, powder, chemical, steam, and hydraulic plants, and marine service — IT identifies Vogt Drop Forged Steel Valves at work for Victory!

TOMORROW — Vogt Valves will again be available to ALL industries where sure and safe control of high pressure and high temperature liquids and gases is a MUST.

**Now available—a new line of malleable iron chain wheels, interchangeable with Vogt knobbed handwheels, for remote control of valves.*



Consult Catalog F-8 for the world's most complete line of Drop Forged Steel Valves, Fittings and Flanges.

Branch Offices: New York, Philadelphia, Cleveland, Chicago, Dallas.

Vogt DROP FORGED STEEL Valves

HENRY VOGT MACHINE CO., LOUISVILLE 10, KENTUCKY

The Engineer Says

"WHAT A RELIEF!"

Many a power plant engineer has made this remark after installing GARLOCK Packings and Gaskets. No more leaks in boilers, pipe lines and pumps—and everybody's happy!

GARLOCK products give long, dependable service because they are manufactured in our own plant and are *quality-controlled* from raw material to finished product.

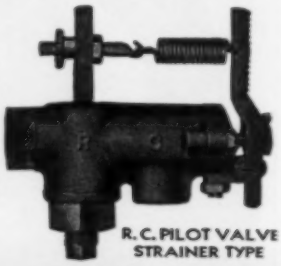
THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK
Manufacturers of GARLOCK *Packings, Gaskets and* KLOZURE *Oil Seals*
In Canada: The Garlock Packing Company of Canada Ltd.
Montreal, Que.

GARLOCK 234 gives long, dependable service on rotary or centrifugal pumps handling hot water, cold water, caustic solutions or weak acids. All sizes from ⅛" to 1¼".

Garlock

R. C. PILOT VALVES FOR POSITIVE CONTROL

R-C Unloader Pilot Valves (plain or strainer type) are standard on many leading compressors . . . installed as replacements on thousands of compressors in all parts of the U. S. A. and overseas. The R-C valve—positive in action—cannot chatter . . . it's always in open or closed position. Adjustment is provided for any unload-to-load range from 3% to 30% of maximum receiver pressure. Install an R-C Unloader Pilot valve—let performance prove its value. Specify air pressure and range of on-and-off operation desired. Write for price and recommendation.



R. C. PILOT VALVE
STRAINER TYPE

R. CONRADER CO.

1207 FRENCH STREET - ERIE, PA.

PILOT VALVES for Portable and Stationary Air Compressors provided with Unloaders

THIS IS THE MURPHY BALL FLOAT TRAP

★ GUARANTEED

LITERATURE AND PRICES ON REQUEST

½" Pipe Size Only

YES...

Guaranteed to eliminate entirely all water and oil from small compressed air installations. Guaranteed as to workmanship and materials, too. Entirely mechanical and automatic. No attention . . . no wear.

Murphy *knows* compressed air. Write for our literature, or state your problem. Our engineers are at your service.

GUARANTEED COMPRESSED AIR PRODUCTS

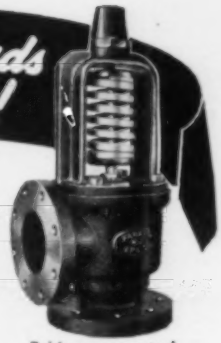
AFTERCOOLERS • SEPARATORS • STRAINERS • TRAPS
SPRAY GUNS • PISTOL SPRAYERS

JAS. A. MURPHY & CO.

HAMILTON, OHIO, U.S.A.

Moisture Elimination Up To 3000 Pounds Per Square Inch

No Packing Glands - SURE RELIEF!



No packing-glands, no stuffing-boxes on the stem of this FARRIS Relief Valve—to accidentally draw down too tight and prevent accurate operation. FARRIS packless "Flexseal" construction for dependable action under back-pressure conditions.

This FARRIS Liquid Relief Valve No. 1250 features sturdy construction for reliable, trouble-free operation and long life.

Built in semi-steel, cast steel and bronze, for pressures to 600 lbs. Sizes 2½" to 6".

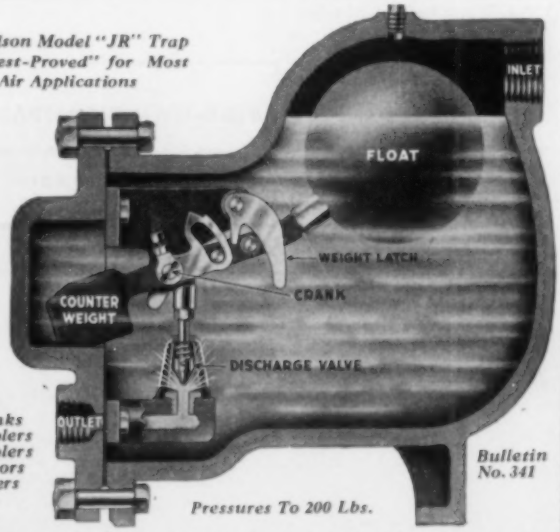
FARRIS Relief and Safety Valves are precision machined to deliver precision operation in protecting your equipment. You're always safe with a FARRIS! Write today for our Specifications Bulletin

FARRIS ENGINEERING CO.,
354 Commercial Ave., Palisades Park, N. J.

Farris
SAFETY and RELIEF VALVES

NICHOLSON
America's Fastest-Acting
COMPRESSED-AIR TRAP

Nicholson Model "JR" Trap Is "Test-Proved" for Most Air Applications



For Air Tanks Intercoolers Aftercoolers Separators Receivers Etc.

Pressures To 200 Lbs.

Bulletin No. 341

Due to their exclusive weight-operated design, Nicholson Model "JR" Compressed Air Traps open and close instantaneously, giving full, faster drainage of water and oil. Model "JR" has been a record-making trouble-shooter for hard-pushed warplant equipment. Send for details.

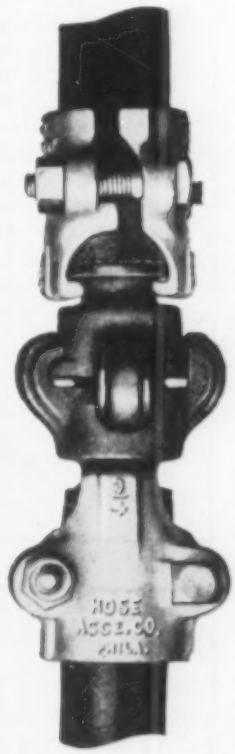
W. H. NICHOLSON & CO.
180 OREGON ST., WILKES-BARRE, PA.
Valves • Traps • Steam Specialties

Calculations show that the average compressor expense of air which is wasted through an opening only 1/16" in diameter costs $1.40 per eight hour day.

Leaks on any kind of a line whether air, steam, gases, of high or low pressure cost you money . . . money that should be carrying its share of power to your tools, helping your operators to get the best out of them.

For example, for manifold outlets on air compressors, specify LE-HI Series 100 Universal Type Hose Couplings. They're tough . . . can take abuse and couple or uncouple without a fight. Lower cost operation and production will result because these rugged hose couplings "cling" to the hose without danger of blowing off under constant vibration.

Why keep losing money because of improper hose fittings? Ask your distributor about LE-HI Hose Couplings . . . a complete line for industrial and construction use.



LE-HI Series 100 Universal Type Hose Couplings for a quick-acting connection on manifold outlets on air compressors and many special uses.

LE-HI Series 400 High Pressure Female Hose Coupling and companion Male Unit, Series 500. For use on High Pressure Air, or Steam Hose Lines or for Water Hose Service.

Send today for your copy of LE-HI Catalog No. 644.

SOLD ONLY THROUGH DISTRIBUTORS

HOSE ACCESSORIES CO.
2716 N. SEVENTEENTH STREET
PHILADELPHIA 32, PENNA.

LE-HI
HIGH and LOW PRESSURE
HOSE COUPLINGS

BEARIUM METAL

PROVED BY YEARS OF USE IN THOUSANDS OF APPLICATIONS

For more than 20 years—in applications ranging from motion picture projectors to bulldozers—the amazing properties of **BEARIUM METAL** have greatly reduced operating costs and solved countless frictional problems everywhere.

Non-seizing and non-scoring—even should lubrication completely fail—**BEARIUM METAL** provides not only every desirable quality found in other bearing alloys, but possesses features in addition that are *exclusive*.

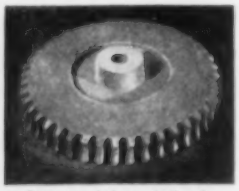
Write for full information on this amazingly different bearing bronze.

BEARIUM METALS CORP.
270 State St. Rochester 4, N. Y.

The Ultimate Development for Bearing Services

Bearium Pump Bearing

Bearium Turbine Bearing



Bearium Worm Wheel

If it's **PNEUMATIC** *it needs a*

NORGREN *Lubricator*

Air-driven tools and cylinders perform *faster, better, longer* with a NORGREN LUBRICATOR in the air line. Automatically and continuously injects just the right amount of oil into air stream . . . maintaining protective film on moving parts.

Any desired degree of feed, needle valve adjustment. Visible feed ends guessing. No pressure loss.

Write for detailed information. C. A. Norgren Co., 220 Santa Fe Drive . . . Denver 9, Colorado

Norgren

New Model A-1 *Pur-O-fier*

For Compressed Air

Positive purification of air lines is assured with this new Model A-1 Pur-O-fier designed to eliminate free moisture, oil and foreign matter in small compressed air systems. It operates with from 1 to 5 cubic feet of air and for intermittent operations is extremely sensitive to the slightest movement of air. Weighing only 1¼ lbs., this new unit is just 3⅛" in diameter by 5⁹⁄₁₆" deep including plastic, transparent entrainment sump. Model A-1 Pur-O-fier requires no maintenance.

Drain valve permits easy and quick draining of the sump. Pur-O-fier uses positive, centrifugal action as a medium for purification and can be used for air-operated instrument controls, air-operated gauges of the precision and checking type, and air-operated cleaning devices of many types. This unit will operate effectively from 1 to 75 P.S.I. Write for bulletin No. 11 giving complete details.

Patent applied for

Write for New Bulletin No. 11 giving complete specifications and applications

BIRD-WHITE COMPANY
Dept. CA, 3119 W. Lake Street
CHICAGO, ILLINOIS

NEW YORK OFFICE
60 East 42nd Street

MAIN OFFICE
AND WORKS
BUFFALO, N. Y.

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Secretary and Mgr. of Sales

ATLAS STEEL CASTING COMPANY

OPEN HEARTH & ELECTRIC STEEL

1963 ELMWOOD AVENUE

BUFFALO, N. Y.

Saying "No" to an Old Friend is the hardest thing in the World

Four stars awarded for excellence in war production.

When you ask for *American Hammered* Piston Rings—it's a big compliment. We worked for years to make our rings so good you *would* ask for them.

But in war, ships, planes and machines call for millions of rings that take extra-special skill, experience and facilities to make. We've turned out over 100,000,000 rings, longer-wearing (three to four times the life between overhauls) more precise (tolerances down to .000003-in) huskier (two to three times previous tensile strength). But we've sometimes had to disappoint some old and valued customers on delivery, when they could get along with other rings that weren't so vital to the forces overseas.

We hate this situation worse than you do—and are looking forward to the day when we can again give you Rings in Every Size—of Every Type—for Every Purpose—IMMEDIATELY.

KOPPERS COMPANY, INC.
AMERICAN HAMMERED PISTON RING DIVISION
Baltimore 3, Maryland

KOPPERS
THE INDUSTRY THAT SERVES ALL INDUSTRY

Buy More War Bonds—and Keep Them!

Air-arteries under the Adirondacks!

FROM THIS BATTERY of synchronous motor-driven compressors are supplied the *lifelines* of a modern mine — compressed-air lines for operating equipment at work more than a thousand feet under the Adirondacks.

Because war-producing mines will *stop* without air power, dependability and top performance are necessary "musts" for air compressor electric motor-drives. These (you-can-bet-your-bottom-dollar-on) 400 h.p. E-M Synchronous Motors deliver the power to force air down the 12-inch lines . . . for jackhammers, shovels, hoists and other air-driven tools deep in the mine.

Your important compressors demand built-for-the-job motors of recognized dependability. That E-M motors are *used on a big share of* ALL *large compressor drives* is pretty good proof to *you* that it pays to "specify E-M."

You get these typical advantages with

E-M

SYNCHRONOUS MOTORS For Compressor Drives

HIGH EFFICIENCY . . . lower power cost per unit of air output than any other type of electric drive.

IMPROVED POWER FACTOR . . . offsets "deadhead" current caused by induction motors. Boosts power system efficiency and reduces power costs.

AUTOMATIC CONTROL . . . Push button starting. Polarized field-frequency control keeps compressor running during voltage dips.

LOW INSTALLATION COST . . . only two motor parts, stator and rotor. Minimum foundation cost.

Get E-Mgineered advantages on your next compressors. Call an E-M sales engineer . . . he is a specialist in compressor-motor applications.

ELECTRIC MACHINERY MANUFACTURING COMPANY
Minneapolis 13, Minnesota

SPECIFY E-M SYNCHRONOUS MOTORS FOR COMPRESSOR DRIVES

A2010

HIGH-SPEED | LOW-SPEED | ENGINE-TYPE | "PACKAGED"

Stop that thieving demon *RUST* with new

SHELL RUST-PREVENTIVES

WHAT IS RUST'S annual "cut" in your business? How much should you charge off to this thievery?

Probably much more than you think!

Because the cost of rust is the total of a lot of big and little losses. Depreciating equipment . . . ruined materials . . . worthless finished products. *Plus time wasted all along the line!*

That is no new story. *The news is that Shell has perfected and now presents a complete line of Rust Preventives* . . . the new Shell Ensis Rust Preventives for coating metals . . . the new Shell Tellus Oils for lubrication.

Shell Ensis Rust Preventives embody a complete line of oils, fluids and compounds. They are available in various grades and provide protection against the dangers of exposure. Their protective coatings range from thin, transparent films for indoor use to heavy, abrasion-and-weather-resistant coatings for outdoors.

Shell Tellus Oils do not *remove* rust . . . However, where moisture is a factor, special rust-inhibiting qualities built into them afford protection against the formation of rust, without sacrifice of other valuable characteristics.

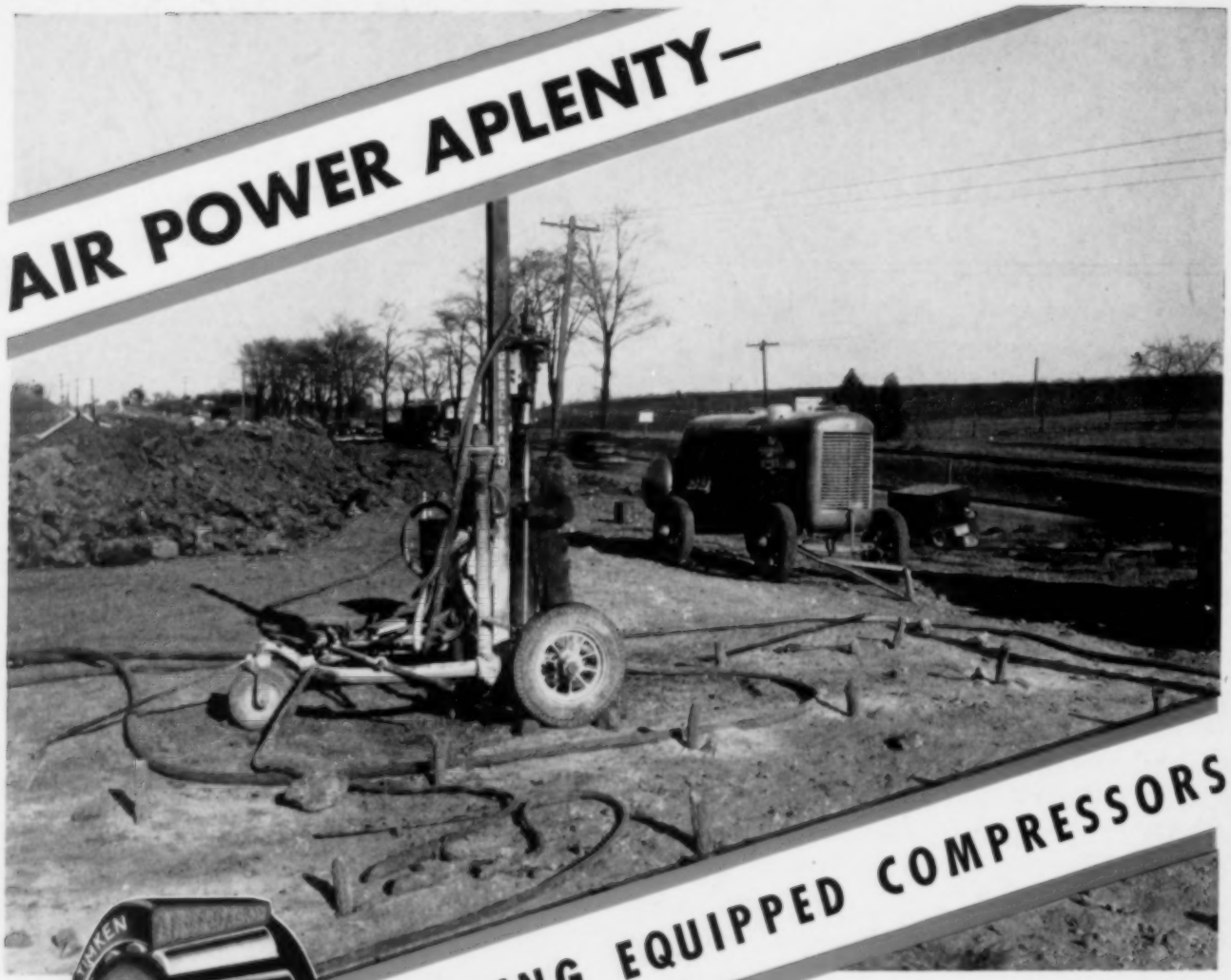
Call in the Shell Man. Let him make a study of your operation, and advise you the proper Rust Preventive product for your plant. Write Shell Oil Co. Inc., 50 W. 50th St., New York 20, N. Y. . . . or 100 Bush St., San Francisco 6, California.

SHELL ENSIS Rust Preventive Coatings

SHELL TELLUS Rust Preventive Lubricating Oils

SHELL

AIR POWER APLENTY—



WITH TIMKEN BEARING EQUIPPED COMPRESSORS

A typical example of modern efficiency in the production and application of compressed air is shown in this photograph, taken on a road building job.

Ingersoll-Rand 315-CFN Portable Compressors are seen supplying power to Ingersoll-Rand Model FM-2 wagon drills. Hidden from view, but none the less important to the performance and endurance of this equipment are Timken Tapered Roller Bearings — put there by the foresight of the manufacturer to prevent friction and wear; to afford full protection against radial, thrust and combined loads; and to hold moving parts in correct and constant alignment. They are used on the crank shaft and in the road wheels of the compressors and in the worm gear drives and wheels of the wagon drills.

Ingersoll-Rand has proved, by years of experience with them, that Timken Bearings can be depended upon to provide anti-friction efficiency in full — and so have users of Ingersoll-Rand compressors. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS